ADF&G TECHNICAL DATA REPORT NO. 207
(Limited Distribution)

STATE OF ALASKA
Steve Cowper, Governor

BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES FOR 1983

Edited by:
Brian G. Bue
and
Stephen M. Fried

June 1987

ALASKA DEPARTMENT OF FISH AND GAME
P.O. Box 3-2000, Juneau, Alaska 99802

Don W. Collinsworth
Commissioner

ADF&G TECHNICAL DATA REPORTS

This series of reports is designed to facilitate prompt reporting of data from studies conducted by the Alaska Department of Fish and Game, especially studies which may be of direct and immediate interest to scientists of other agencies.

The primary purpose of these reports is presentation of data. Description of programs and data collection methods is included only to the extent required for interpretation of the data. Analysis is generally limited to that necessary for clarification of data collection methods and interpretation of the basic data. No attempt is made in these reports to present analysis of the data relative to its ultimate or intended use.

Data presented in these reports is intended to be final, however, some revisions may occasionally be necessary. Minor revision will be made via errata sheets. Major revisions will be made in the form of revised reports.

BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES FOR 1983

Edited by:

Brian G. Bue and Stephen M. Fried

Technical Data Report No. 207
Alaska Department of Fish and Game
Division of Commercial Fisheries
Anchorage, Alaska

June 1987

TABLE OF CONTENTS

Page

LIST OF TABLES i

LIST OF APPENDICES v

ABSTRACT vi

FOREWORD vii

KVICHAK RIVER SOCKEYE SALMON SMOLT STUDIES FOR 1983

Introduction 1

Materials and Methods 1

Results and Discussion 3

Literature Cited 4

Appendix A 20

NAKNEK, EGEGIK, AND UGASHIK RIVERS SOCKEYE SALMON SMOLT STUDIES FOR 1983

Introduction 36

Materials and Methods 37

Results and Discussion 38

Naknek River 38
Egegik River 39
Ugashisk River 40

Literature Cited 41

WOOD RIVER SOCKEYE SALMON SMOLT STUDIES FOR 1083

Introduction 72

Materials and Methods 72

Results and Discussion 73

Literature Cited 75

NUYAKUK RIVER SOCKEYE SALMON SMOLT STUDIES FOR 1983

Introduction 97

Materials and Methods 97

TABLE OF CONTENTS (Continued)

	Page
Results and Discussion	98
Literature Cited	100

LIST OF TABLES

Table — Page

KVICHAK RIVER SOCKEYE SALMON SMOLT STUDIES FOR 1983

1. Sonar counts recorded from three 14 transducer arrays at the sockeye salmon smolt counting site on the Kvichak River, Bristol Bay, Alaska, 1983. False counts were deleted, and interpolations were made for time missed when sonar not operated 7

2. Daily number of sockeye salmon smolts migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1983 8

3. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Kvichak River, Bristol Bay, Alaska, 1983 9

4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Kvichak River, Bristol Bay, Alaska, 1983 10

5. Age composition of total migration, and mean fork length (mm) and weight (g) by age class for sockeye salmon smolt, Kvichak River, Bristol Bay, Alaska, 1955-1983 11

6. Sockeye salmon spawning escapement, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses),, and number of smolt produced per spawner for 1956-1981 brood years 13

7. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1952-1982 brood years, Kvichak River, Bristol Bay, Alaska 15

8. Climatological and hydrological observations made at sockeye salmon smolt counting site, Kvichak River, Bristol Bay, Alaska, 1983 17

9. Water temperatures at sockeye salmon smolt counting site, Kvichak River, Bristol Bay, Alaska, 1963-1983 19

NAKNEK, EGEGIK, AND UGASHIK RIVERS SOCKEYE SALMON SMOLT STUDIES FOR 1983

1. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Naknek River, Bristol Bay, Alaska, 1983. False counts were deleted, and interpolations were made for time missed when sonar not operated 45

2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Naknek River, Bristol Bay, Alaska, 1983 . . . 47

LIST OF TABLES (Continued)

Table | Page

NAKNEK, EGEGIK, AND UGASHIK RIVERS SOCKEYE SALMON SMOLT STUDIES FOR 1983 (Continued)

3. Adjustment factor used to expand sonar counts into estimated numbers of sockeye salmon smolts, Naknek River, Bristol Bay, Alaska, 1983 49

4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Naknek River, Bristol Bay, Alaska, 1983 . . 51

5. Mean fork length (mm) and weight (g) of sockeye salmon smolt sampled from the Naknek River, Bristol Bay, Alaska, 1957-1983 . . 53

6. Climatological and hydrological observations made at sockeye salmon smolt counting site, Naknek River, Bristol Bay, Alaska, 1983 54

7. Water temperatures at sockeye salmon smolt counting site, Naknek River, Bristol Bay, Alaska, 1967-1983 56

8. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Egegik River, Bristol Bay, Alaska, 1983 57

9. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Egegik River, Bristol Bay, Alaska, 1983 . 58

10. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Egegik River, Bristol Bay, Alaska, 1983 59

11. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Egegik River, Bristol Bay, Alaska, 1983 . . 60

12. Mean fork length (mm) and weight (g) of sockeye salmon smolt sampled from the Egegik River, Bristol Bay, Alaska, 1939-1983 . . 61

13. Climatological and hydrological observations made at sockeye salmon smolt counting site, Egegik River, Bristol Bay, Alaska, 1983 62

14. Sonar counts recorded from two 10 transducer arrays at the sockeye salmon smolt counting site on the Ugashik River, Bristol Bay, Alaska, 1983 63

15. Daily number of sockeye and coho salmon smolt migrating seaward, estimated with a sonar unit, Ugashik River, Bristol Bay, Alaska, 1983 64

LIST OF TABLES (Continued)

Table — Page

NAKNEK, EGEGIK, AND UGASHIK RIVERS SOCKEYE SALMON SMOLT STUDIES FOR 1983 (Continued)

16. Adjustment factors used to expand sonar counts into estimated numbers of sockeye and coho salmon smolt, Ugashik River, Bristol Bay, Alaska, 1983 66

17. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Ugashik River, Bristol Bay, Alaska, 1983 . 67

18. Mean fork length (mm) and weight (g) of coho salmon smolt captured in fyke nets, Ugashik River, Bristol Bay, Alaska, 1983 . 69

19. Mean fork length (mm) and weight (g) of sockeye salmon smolt sampled from the Ugashik River, Bristol Bay, Alaska, 1958-1983 . 70

20. Climatological and hydrological observations made at sockeye salmon smolt counting site, Ugashik River, Bristol Bay, Alaska, 1983 71

WOOD RIVER SOCKEYE SALMON SMOLT STUDIES FOR 1983

1. Sonar counts recorded from four 10 transducer arrays at the sockeye salmon smolt counting site on the Wood River, Bristol Bay, Alaska, 1983. False counts were deleted, and interpolations were made for time missed when sonar not operated 77

2. Percentage of total unexpanded sonar counts recorded over each array, Wood River, Bristol Bay, Alaska, 1983. False counts were deleted, and interpolations were made for time missed when sonar not operated 79

3. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Wood River, Bristol Bay, Alaska, 1983 80

4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Wood River, Bristol Bay, Alaska, 1983 . . 83

5. Age composition of total migration, and mean fork length (mm) and weight (g) by age class, for sockeye salmon smolt, Wood River, Bristol Bay, Alaska, 1951-1983 86

6. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Wood River, Bristol Bay, Alaska, 1983 88

7. Infection of sockeye salmon smolts by the cestode *Triaenophorus crassus*, Wood River, Bristol Bay, Alaska, 1983 90

LIST OF TABLES (Continued)

Table — Page

WOOD RIVER SOCKEYE SALMON SMOLT STUDIES FOR 1983 (Continued)

8. Infection of sockeye salmon smolt by the cestode *Triaenophorus crassus*, Wood River, Bristol Bay, Alaska, 1983 91

9. Sockeye salmon spawning escapements, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1972-1981 brood years, Wood River, Bristol Bay, Alaska 92

10. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1972-1981 brood years, Wood River, Bristol Bay, Alaska . . . 93

11. Water temperatures and depths at field camp site, head of Wood River (outlet of Lake Aleknagik), Bristol Bay, Alaska, 1983 . . 94

12. Water temperatures and depths at field camp site, head of Wood River (outlet of Lake Aleknagik), Bristol Bay, Alaska, 1975-1983 96

NUYAKUK RIVER SOCKEYE SALMON SMOLT STUDIES FOR 1083

1. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Nuyakuk River, Bristol Bay, Alaska, 1983. False counts were deleted, and interpolations were made for time missed when sonar not operated 101

2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Nuyakuk River, Bristol Bay, Alaska, 1983 . . 102

3. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Nuyakuk River, Bristol Bay, Alaska, 1983 104

4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Nuyakuk River, Bristol Bay, Alaska, 1983 106

5. Age composition of total migration, and mean fork length (mm) and weight (g) by age class, for sockeye salmon smolt, Nuyakuk River, Bristol Bay, Alaska, 1978, 1982, and 1983 108

6. Climatological and hydrological observations made at sockeye salmon smolt counting site, Nuyakuk River, Bristol Bay, Alaska, 1983 109

LIST OF APPENDICES

Page

KVICHAK RIVER SOCKEYE SALMON SMOLT STUDIES FOR 1983

Appendix A 21

A.1 Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1972 23

A.2 Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1973 25

A.3 Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1974 26

A.4 Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1976 27

A.5 Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1977 28

A.6 Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1978 29

A.7 Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1979 30

A.8 Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1980 31

A.9 Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1981 33

A.10 Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1982 34

ABSTRACT

Sockeye salmon *(Oncorhynchus nerka)* smolt studies were conducted on the Kvichak, Naknek, Egegik, Ugashik, Wood, and Nuyakuk Rivers within Bristol Bay, Alaska, during 1983. Estimates of numbers of smolt migrating to sea, based upon data obtained from sonar equipment, were 82,794,000 from Kvichak; 53,319,000 from Naknek; 18,767,000 from Egegik; 44,034,000 from Ugashik; 23,728,000 from Wood; and 30,134,000 from Nuyakuk. Fyke net samples indicated that age I smolt, from 1981 brood year spawning escapements, were the dominant age class in four out of the six river systems (percent of age I smolt: 69, Naknek; 71, Ugashik; 83, Wood; 96, Nuyakuk). Age II smolt, from 1980 escapements, were the dominant age class in the remaining two systems (percent of age II smolt: 92, Kvichak; 88, Egegik).

KEY WORDS: juvenile sockeye salmon, *Oncorhynchus nerka*, juvenile migration, sonar, Bristol Bay, Kvichak River, Naknek River, Egegik River, Ugashik River, Wood River, Nuyakuk River.

FOREWORD

This report is a continuation of a series of Alaska Department of Fish and Game Technical Data Reports documenting methods and results of projects conducted to estimate numbers and age composition of sockeye salmon *(Oncorhynchus nerka)* smolt migrating from Bristol Bay river and lake systems. Smolt data are used both to forecast adult returns and to determine optimum spawning escapement for Bristol Bay fresh water systems. In 1983, sonar equipment was used to estimate the number of smolt migrating from the Kvichak, Naknek, Egegik, Ugashik, Wood, and Nuyakuk River systems. Fyke nets were used to capture samples of smolt to obtain age, length, and weight data. Smolt which have remained within fresh water for one winter after hatching will have formed one annular mark on their scales and are referred to as age I smolt. Smolt which have spent two winters within fresh water after hatching will have formed two annual marks and are referred to as age II smolt.

KVICHAK RIVER SOCKEYE SALMON SMOLT STUDIES FOR 1983

By

Donald Bill
Alaska Department of Fish and Game
Division of Commercial Fisheries
King Salmon, Alaska

and

Stephen M. Fried and Henry J. Yuen
Alaska Department of Fish and Game
Division of Commercial Fisheries
Anchorage, Alaska

INTRODUCTION

Estimates of numbers of seaward migrating sockeye salmon *(Oncorhynchus nerka)* smolt have been made for the Kvichak River system since 1971 using sonar gear developed by Bendix Corporation. Prior to that time fyke nets were used to calculated abundance indices (Kerns 1961; Russell 1972; Paulus and McCurdy 1972; Parker 1974a and 1974b). Abundance and age composition data have been used to forecast adult returns and to evaluate spawning escapement levels needed for optimum production.

Specific objectives of 1983 studies were to estimate the number of sockeye salmon smolt migrating to sea, to determine the age composition of the smolt population, to collect length and weight data for smolt, and to record climatological and hydrological data which could influence smolt migratory patterns.

MATERIALS AND METHODS

The sonar system consisted of a single control unit and three 3.3-m (11-ft) long plastic ladder-shaped arrays, each housing 14 transducers. The combined sonar beam produced by each array was 3.7 m (12.2 ft) wide. Arrays were anchored on the river bed, and their transducers were connected to the control unit with coaxial cables. Installation and operation of the gear followed procedures similar to those described by Randall (1977). The total number of sonar counts recorded by each array was printed by the control unit every 15 minutes. Sonar counts were converted to estimates of smolt numbers by subtracting false counts, interpolating counts during missed time periods, adjusting counts for differences in river velocity among arrays, expanding counts to estimate numbers of smolt passing the transect site in areas not covered by sonar beams, and multiplying counts by the actual number of smolt which generated a single sonar count.

A disabling switch was used to turn off the sonar counting unit during times when ice, debris, boat traffic, etc. generated false counts. The time, in seconds, that the unit was disabled was automatically printed at the end of each specified counting interval. Estimates of valid (smolt) sonar counts during periods when the unit was disabled were calculated by linear interpolation. Any false counts noted during times when the unit was not disabled were subtracted from period totals.

Water current velocities were measured behind each array three times during the season so that sonar pulse rate could be adjusted. This minimized over- and under-counting errors, since residence time of smolt within the sonar beam decreased as water current speed increased.

Counts from each array were expanded to estimate numbers of smolt migrating in sections of the river not covered by the arrays. Expansion of counts was based on the lateral distribution of smolt across the counting site transect, which was estimated visually and from information gathered from a side scanning sonar unit.

The sonar system was designed to count biomass rather than individual smolt and was calibrated at the factory to register one count for the biomass equivalent of 10 smolt weighing a total of 83 g (based upon the weighted mean of all Kvichak smolt weight data available prior to 1971). In past studies, adjusted sonar counts were multiplied by 10 to obtain final estimates of smolt numbers. However, since mean smolt weight varied during the season as well as among years, more accurate final estimates of smolt numbers should be obtained using actual mean smolt weight data from daily fyke net catches. Therefore, daily adjusted smolt counts were multiplied by a correction factor (F):

$$F = 10\ (8.3 / W), \text{ where}$$

W = daily mean weight of smolt from fyke net samples. Correction factors were also calculated and applied to past estimates (1972-1982) (Appendix A) so that production of smolt and adults from past escapements could be recalculated for the present study.

A 1.5-m to 1.5-m (5-ft by 5-ft) fyke net was fished downstream of the center and offshore sonar arrays. Captured smolt were identified according to species, weighed (g), measured (fork length, mm), and aged from scale samples. This data was used to apportion sonar counts according to age class and salmonid species.

Samples of at least 400 sockeye salmon smolt were used to estimate age class composition for each 24-hour sampling period when available. If this number of smolt was not captured during a 24-hour period, samples from subsequent periods were combined until a total of at least 400 smolt was obtained. Samples of 400 smolt produced estimates of the proportion of age I or age II smolt which were within 5% of the actual proportion (at the 0.05 significance level) for actual age class proportions ranging from 0.95 to 0.05 (Cochran 1963).

To obtain daily age data for 400 sockeye salmon smolt, it was necessary to decrease sampling time. Therefore, scale samples, weights and lengths were

obtained only from about 150 smolt each day. An additional 250 smolt were measured for length data but were not weighed or used for scale samples. After the field season, smolt for which only length measurements had been obtained were assigned a weight and an age based upon analysis of available age, weight, and length data.

RESULTS AND DISCUSSION

A total of 1,790,787 sonar counts were recorded during the season (Table 1). Estimated total number of smolt was 82,793,899 (Table 2). Peak migration past the counting site occurred during 24-25 May, when 29% of the total smolt population migrated seaward. Numbers of smolt per sonar count tended to increase as the season progressed (range, 9.3 to 12.7 smolt per count) (Table 3). This was caused by the tendency of older, larger smolt to migrate to seas earlier in the season than younger, smaller smolt (Table 4).

A total of 7,640 smolt were sampled to obtain data on age, length and weight (Table 4). Age-class composition of the total smolt population was estimated to be 7.9% age I (1981 brood year) and 92.1% age II (1980 brood year). Mean lengths of age I and II smolt were 80 mm and 98 mm, respectively. Mean weights of age I and II smolt were 4.9 g and 8.5 g, respectively. Mean lengths and weights of both age classes were lower than the overall means for 1955-1982 (Table 5).

Total smolt production from the 1980 brood year spawning escapement of 17,505,268 sockeye salmon was 12.948 smolt per spawner (150,421,026 age I smolt migrated to sea in 1982; 76,244,773 age II smolt migrated to sea in 1983) (Table 6). This was the second lowest smolt production recorded since the sonar program began (range, 1968-1980 brood years, 11.120 to 51.753 smolt per spawner). Average marine survival for smolt produced by the 1968-1979 brood years has been about 9% for age I smolt (i.e. an average of 0.094 adults have returned for each age I smolt produced), and about 12% for age II smolt (i.e. an average of 0.121 adults have returned for each age II smolt produced) (Table 7).

Estimates of smolt numbers based upon sonar equipment have been more reasonable than estimates based upon fyke net sampling schemes (Tables 6 and 7). Prior to use of sonar equipment, estimates of smolt produced per spawner were much too low (mean fyke net estimate, 0.376; mean sonar estimate, 26.551), since estimates of smolt survival (i.e. adults produced per smolt) were obviously too high (mean fyke net estimates, 5.20 and 14.28 adults produced per age I and II smolt, respectively; mean sonar estimates, 0.094 and 0.121 adults per age I and II smolt, respectively).

River and weather conditions were recorded at the sonar site from 19 May until 14 June (Table 8). Ice floated past the site intermittently until 22 May. Mean water temperature during the project was 7.9^{o}C (range, 5.2 to 10.5^{o}C). This was the third highest mean water temperature recorded since 1963 (mean, 1963-1982, 5.3^{o}C) (Table 9). During peak migration of smolt, 24-25 May, mean water temperature at the counting site was between 6.5 and 7.5^{o} C (Table 8).

LITERATURE CITED

Bergstrom, D.J., and H.J. Yuen. 1981. 1980 Kvichak River sockeye salmon smolt studies. Pages 1-15 in C.P. Meacham, editor. 1980 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 63, Juneau, Alaska.

Bill, D. 1984. 1982 Kvichak River sockeye salmon smolt studies. Pages 2-13 in D.M. Eggers and H.J. Yuen, editors. 1982 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 103, Juneau, Alaska.

Cochran, W.G. 1963. Sampling Techniques. Second Edition. John Wiley and Sons, New York, N.Y. 413 p.

Kerns, O.E. 1961. Abundance and age of Kvichak River red salmon smolts. Fishery Bulletin 189(61): 301-320.

Krasnowski, P. 1975. 1975 Kvichak River sockeye salmon smolt studies. Pages 1-13 in P. Krasnowski, editor. 1974 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 20, Juneau, Alaska.

Marriott, R.A. 1965. 1963 Kvichak River red salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 48, Juneau, Alaska.

McCurdy, M.L., and R.D. Paulus. 1972. 1969 Kvichak River sockeye salmon smolt studies. Pages 1-34 in M.L. McCurdy, editor. 1969 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and GAme, Division of Commercial Fisheries, Technical Data Report 3, Juneau, Alaska.

Parker, K.P. 1974a. 1972 Kvichak River sockeye salmon smolt studies. Pages 1-37 in K.P. Parker, editor. 1972 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 13, Juneau, Alaska.

Parker, K.P. 1974b. 1973 Kvichak River sockeye salmon smolt studies. Pages 1-22 in K.P. Parker, editor. 1973 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 14, Juneau, Alaska.

Paulus, R., and M. McCurdy. 1969. 1968 Kvichak River sockeye salmon *(Oncorhynchus nerka)* smolt studies. Pages 1-45 in M.L. McCurdy, editor. 1968 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 138, Juneau, Alaska.

LITERATURE CITED (Continued)

Paulus, R.D., and M.L. McCurdy. 1972. 1970 Kvichak River sockeye salmon smolt studies. Pages 1-13 in P.A. Russell, editor. 1970 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 4, Juneau, Alaska.

Paulus, R., and K. Parker. 1974. Kvichak River sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 166, Juneau, Alaska.

Pennoyer, S. 1966. 1965 Kvichak River red salmon *(Oncorhynchus nerka)* smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 83, Juneau, Alaska.

Pennoyer, S., and M.C. Seibel. 1965. 1964 Kvichak River red salmon *(Oncorhynchus nerka)* smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 58, Juneau, Alaska.

Pennoyer, S., and D.M. Stewart. 1967. 1966 Kvichak River red salmon *(Oncorhynchus nerka)* smolt studies. In D.M. Stewart, editor. 1966 Bristol Bay red salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 102, Juneau, Alaska.

Pennoyer, S., and D.M. Stewart. 1969. 1967 Kvichak River red salmon *(Oncorhynchus nerka)* smolt studies. Pages 4-17 in D.M. Stewart, editor. 1967 Bristol Bay red salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 134, Juneau, Alaska.

Randall, R.C. 1976. 1975 Kvichak River sockeye salmon smolt studies. Pages 1-9 in P. Krasnowski, editor. 1975 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 25, Juneau, Alaska.

Randall, R.C. 1977. 1976 Kvichak River sockeye salmon smolt studies. Pages 1-13 in N. Newcome, editor. 1976 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report No. 33, Juneau, Alaska.

Randall, R.C. 1978. 1977 Kvichak River sockeye salmon smolt studies. Pages 1-5 in H. Yuen, editor. 1977 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 41, Juneau, Alaska.

Russell, P.A. 1972. 1971 Kvichak River sockeye salmon smolt studies. Pages 1-28 in P.A. Russell and M.L. McCurdy, editors. 1971 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 2, Juneau, Alaska.

LITERATURE CITED (Continued)

Yuen, H.J. 1980a. 1978 Kvichak River sockeye salmon smolt studies. Pages 1-17 in C.P. Meacham, editor. 1978 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 44, Juneau, Alaska.

Yuen, H.J. 1980b. 1979 Kvichak River sockeye salmon smolt studies. Pages 1-12 in C.P. Meacham, editor. 1979 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 46, Juneau, Alaska.

Yuen, H.J., and M. Wise. 1982. 1981 Kvichak River sockeye salmon smolt studies. Pages 2-15 in D.C. Huttunen, editor. 1981 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 73, Juneau, Alaska.

Table 1. Sonar counts recorded from three 14 transducer arrays at the sockeye salmon smolt counting site on the Kvichak River, Bristol Bay, Alaska, 1983. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Date a/	Transducer Array			
	Inshore	Center	Offshore	Total
5 19	2,014	2,669	2,810	7,493
5 20	2,964	3,844	3,017	9,825
5 21	12,635	21,273	9,387	43,295
5 22	25,867	52,376	46,570	124,813
5 23	41,589	56,973	79,306	177,868
5 24	36,868	128,487	146,271	311,626
5 25	42,909	105,544	67,705	216,158
5 26	8,611	73,646	50,997	133,254
5 27	25,380	123,860	59,897	209,137
5 28	2,632	42,798	10,888	56,318
5 29	2,622	5,520	17,860	26,002
5 30	1,108	8,071	4,313	13,492
5 31	11,849	54,147	37,647	103,643
6 1	11,464	43,770	35,593	90,827
6 2	4,421	9,919	10,549	24,889
6 3	2,612	4,981	7,540	15,133
6 4	3,416	8,709	8,004	20,129
6 5	1,274	6,618	7,885	15,777
6 6	8,092	33,089	21,831	63,012
6 7	5,194	21,137	12,096	38,427
6 8	1,555	11,310	9,743	22,608
6 9	427	3,050	6,737	10,214
6 10	1,569	3,125	9,572	14,266
6 11	2,007	5,000	11,240	18,247
6 12	1,319	1,439	9,231	11,989
6 13	1,358	1,943	9,044	12,345
Total	261,756	833,298	695,733	1,790,787
Percent	14.62	46.53	38.85	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska, 1983.

Date a/	Age I		Age II		All Ages	
	Number	Percent	Number	Percent	Daily Total	Cumulative Total
5 19	2,678	0.82	324,983	99.18	327,661	327,661
5 20	3,403	0.82	412,875	99.18	416,279	743,940
5 21	15,587	0.82	1,891,155	99.18	1,906,742	2,650,683
5 22	42,409	0.82	5,145,291	99.18	5,187,700	7,838,384
5 23	54,580	0.73	7,422,134	99.27	7,476,714	15,315,098
5 24	427,753	3.00	13,830,709	97.00	14,258,463	29,573,562
5 25	228,902	2.29	9,788,715	97.72	10,017,618	39,591,181
5 26	141,972	2.29	6,071,253	97.72	6,213,226	45,804,407
5 27	164,922	1.75	9,259,204	98.25	9,424,126	55,228,533
5 28	106,861	3.96	2,591,656	96.04	2,698,517	57,927,051
5 29	119,388	9.69	1,112,695	90.31	1,232,084	59,159,135
5 30	60,977	9.69	568,300	90.31	629,277	59,788,413
5 31	389,927	8.13	4,406,230	91.87	4,796,158	64,584,571
6 1	541,160	12.50	3,788,121	87.50	4,329,281	68,913,853
6 2	194,962	16.95	955,510	83.05	1,150,472	70,064,326
6 3	126,477	16.95	619,865	83.05	746,343	70,810,669
6 4	86,327	9.07	865,466	90.93	951,794	71,762,463
6 5	69,973	9.07	701,508	90.93	771,481	72,533,945
6 6	323,209	10.67	2,705,933	89.33	3,029,143	75,563,088
6 7	954,793	47.68	1,047,709	52.32	2,002,502	77,565,590
6 8	640,178	47.68	702,477	52.32	1,342,655	78,908,246
6 9	284,560	47.68	312,252	52.32	596,812	79,505,058
6 10	393,163	47.68	431,424	52.32	824,588	80,329,647
6 11	501,339	47.68	550,127	52.32	1,051,466	81,381,113
6 12	332,228	47.68	364,559	52.32	696,788	82,077,901
6 13	341,387	47.68	374,609	52.32	715,997	82,793,899
Total	6,549,125	7.91	76,244,773	92.09	82,793,899	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 3. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Kvichak River, Bristol Bay, Alaska, 1983.

Date a/	Mean Weight of Smolt (g)	Smolt per Count
5 19	no sample	9.6
5 20	8.6	9.6
5 21	8.3	10.0
5 22	9.0	9.3
5 23	8.8	9.4
5 24	8.3	10.0
5 25	8.1	10.3
5 26	8.2	10.1
5 27	8.4	9.9
5 28	8.2	10.1
5 29	8.0	10.4
5 30	8.1	10.3
5 31	8.2	10.2
6 1	8.2	10.1
6 2	7.9	10.5
6 3	8.1	10.2
6 4	7.8	10.6
6 5	8.1	10.3
6 6	8.0	10.4
6 7	8.0	10.4
6 8	7.3	11.3
6 9	7.1	11.7
6 10	6.6	12.7
6 11	no sample	11.2
6 12	no sample	11.2
6 13	no sample	11.2

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Kvichak River, Bristol Bay, Alaska, 1983.

	Age I					Age II				
Date a/	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5 20					0	99	0.5	8.6	0.10	90
5 21	85	1.0	5.6	0.17	4	97	0.3	8.4	0.06	298
5 22	71	10.3	4.4	0.72	8	99	0.2	9.0	0.05	702
5 23	78	2.2	4.3	0.12	3	100	0.3	8.9	0.06	406
5 24	78	1.4	4.7	0.23	21	98	0.2	8.4	0.04	679
5 25	83	1.1	5.4	0.18	12	96	0.2	8.1	0.05	387
5 26	83	1.4	4.9	0.27	8	98	0.2	8.2	0.04	505
5 27	83	0.8	5.3	0.14	7	98	0.3	8.4	0.06	393
5 29	83	1.0	5.2	0.16	20	96	0.2	8.1	0.05	485
5 30	81	1.6	5.1	0.24	20	98	0.6	8.4	0.13	158
5 31	80	0.6	4.8	0.10	50	98	0.3	8.5	0.07	564
6 1	76	1.1	4.2	0.16	33	99	0.3	8.5	0.07	373
6 2	82	0.6	4.9	0.10	56	98	0.3	8.4	0.08	392
6 3	82	1.1	5.2	0.28	33	98	0.3	8.5	0.09	261
6 4	74	3.3	4.2	0.26	25	99	1.0	8.8	0.31	85
6 5	82	0.8	5.3	0.15	45	97	0.4	8.5	0.09	315
6 6	83	1.0	5.4	0.16	23	96	0.3	8.1	0.06	385
6 7	86	0.6	6.1	0.15	43	96	0.3	8.2	0.07	360
6 8	81	0.5	5.1	0.08	104	97	0.4	8.3	0.10	241
6 10	78	1.2	4.9	0.21	30	100	1.8	9.7	0.45	16
Totals					545					7,095
Means	80		4.9			98		8.5		

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 5. Age composition of total migration, and mean fork length (mm) and weight (g) by age class, for sockeye salmon smolt, Kvichak River, Bristol Bay, Alaska, 1955-1983. A dash (-) indicates data not available.

Year of Migration	Age I			Age II			Age III			Total Estimate
	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	
				Estimates of smolt numbers based upon fyke net sampling						
1955	0.07	89	-	0.93	-	-	0.00	-	-	260,068
1956	0.39	92	-	0.61	116	-	0.00	-	-	77,660
1957	0.72	96	7.3	0.28	120	14.4	0.00	-	-	30,907
1958	0.98	84	4.6	0.02	114	-	0.00	-	-	3,333,953
1959	0.03	80	-	0.97	99	7.6	0.00	-	-	2,863,876
1960	0.10	91	6.3	0.90	108	10.3	0.00	-	-	614,003
1961	0.72	92	6.8	0.28	117	13.1	0.00	-	-	36,164
1962	0.94	82	4.3	0.06	110	9.9	0.00	-	-	1,203,000
1963	0.03	83	4.8	0.97	98	7.5	0.00	-	-	4,229,431
1964	0.22	87	5.2	0.78	108	9.8	0.00	-	-	2,061,586
1965	0.04	90	6.8	0.96	109	11.3	0.00	-	-	1,812,555
1966	0.92	94	7.4	0.08	114	12.6	0.00	-	-	275,761
1967	0.93	86	5.9	0.07	118	14.2	0.00	-	-	3,088,742
1968	0.11	88	5.5	0.89	104	9.2	0.00	-	-	6,123,683
1969	0.52	92	5.7	0.48	109	10.6	0.00	-	-	1,135,344
1970	0.38	91	6.0	0.62	110	11.0	0.00	-	-	483,638
				Estimates of smolt numbers based upon sonar equipment						
1971	0.93	90	5.8	0.07	111	11.1	0.00	-	-	91,682,813
1972	0.01	80	4.2	0.99	106	10.0	0.00	-	-	54,623,559
1973	0.03	86	5.1	0.97	97	8.3	0.00	-	-	196,966,331
1974	0.09	96	8.3	0.79	111	13.1	0.12	124	17.5	27,082,626
1975	0.63	98	8.4	0.37	122	16.4	0.00	-	-	15,632,531
1976	0.97	88	5.8	0.03	121	14.2	0.00	-	-	111,388,180

-Continued-

Table 5. Age composition of total migration, and mean fork length (mm) and weight (g) by age class, for sockeye salmon smolt, Kvichak River, Bristol Bay, Alaska, 1955-1983. A dash (-) indicates data not available (continued).

Year of Migration	Age I			Age II			Age III			Total Estimate
	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	
Estimates of smolt numbers based upon sonar equipment										
1977	0.38	86	5.5	0.62	106	10.1	0.00	-	-	192,578,099
1978	0.12	88	6.0	0.88	97	7.8	0.00	-	-	245,591,014
1979	0.51	90	6.0	0.49	109	10.3	0.00	-	-	55,181,540
1980	0.94	88	5.9	0.06	110	10.7	0.00	-	-	192,853,007
1981	0.89	85	5.4	0.11	108	10.2	0.00	-	-	252,222,769
1982	0.58	84	5.1	0.39	103	9.1	0.00	-	-	239,721,729
Mean		88	5.9		109	10.9				
1983	0.08	80	4.9	0.92	98	8.5	0.00	-	-	82,793,899

Table 6. Sockeye salmon spawning escapement, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1956-1981 brood years, Kvichak River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age I	Age II	Age III	Total	Per Spawner
		Estimates of smolt numbers based upon fyke net sampling				
1956	9,443,318	3,267,274 (54)	2,777,960 (46)	0	6,045,234	0.640
1957	2,842,810	85,916 (13)	552,603 (87)	0	638,519	0.225
1958	534,785	61,400 (86)	10,126 (14)	0	71,526	0.134
1959	680,000	26,038 (27)	72,180 (73)	0	98,218	0.144
1960	14,630,000	1,130,820 (22)	4,116,093 (78)	0	5,246,913	0.359
1961	3,705,849	113,338 (7)	1,603,464 (93)	0	1,716,802	0.463
1962	2,580,884	458,122 (21)	1,748,178 (79)	0	2,206,300	0.855
1963	338,760	64,377 (73)	23,377 (27)	0	87,754	0.259
1964	957,120	252,384 (53)	222,528 (47)	0	474,912	0.496
1965	24,325,926	2,866,214 (34)	5,475,362 (66)	0	8,341,576	0.343
1966	3,775,184	648,321 (55)	541,017 (45)	0	1,189,338	0.315
1967	3,216,208	594,327 (67)	298,282 (33)	0	892,609	0.278
1968	2,557,440	185,356				
		Estimates of smolt numbers based upon sonar equipment				
1968			5,959,383	0	-	-
1969	8,394,204	85,723,430 (61)	54,159,340 (39)	0	139,882,770	16.664
1970	13,935,306	464,219 (<1)	191,842,930 (98)	2,918,768 (1)	195,225,917	14.009
1971	2,387,392	5,123,400 (19)	21,423,246 (81)	0	26,546,646	11.120
1972	1,009,962	2,740,610	-	-	-	-
1973	226,554	-	3,031,287	0	-	-
1974	4,433,844	108,356,892 (49)	114,269,848 (51)	0	222,626,740	50.211
1975	13,140,450	78,308,251 (27)	213,364,470 (73)	0	291,672,721	22.197
1976	1,965,282	32,226,544 (55)	26,423,348 (45)	0	58,649,892	29.843
1977	1,341,144	28,758,191 (73)	10,410,467 (27)	0	39,168,658	29.205

-Continued-

Table 6. Sockeye salmon spawning escapement, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1956-1981 brood years, Kvichak River, Bristol Bay, Alaska. A dash (-) indicates data not available (continued).

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age I	Age II	Age III	Total	Per Spawner
		Estimates of smolt numbers based upon sonar equipment (continued)				
1978	4,149,288	182,442,540 (85)	32,294,536 (15)	0	214,737,076	51.753
1979	11,218,434	219,928,232 (71)	89,300,703 (29)	0	309,228,935	27.564
1980	17,505,268	150,421,026 (62)	76,244,773 (38)	0	199,172,858	12.948
1981	1,754,358	6,549,125				

Table 7. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1952-1982 brood years, Kvichak River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total Spawning Escapement	Age I			Age II		
		Number of Smolt	Adult Returns	Adult Returns per Smolt	Number of Smolt	Adult Returns	Adult Returns per Smolt
Estimates of smolt numbers based upon fyke net sampling							
1952	-	-	17,442,177	-	241,870	3,568,683	14.75
1953	-	18,198	150,000	8.24	47,373	416,438	8.79
1954	-	30,287	108,062	3.57	8,654	638,807	73.82
1955	-	22,253	349,379	15.70	66,679	1,111,184	16.66
1956	9,443,318	3,267,274	31,072,719	9.51	2,777,960	7,669,165	2.76
1957	2,842,810	85,916	477,643	5.56	552,603	3,492,512	6.32
1958	534,785	61,400	121,131	1.97	10,126	157,830	15.59
1959	680,000	26,038	321,845	12.36	72,180	212,080	2.94
1960	14,630,000	1,130,820	1,841,471	1.63	4,116,093	52,434,234	12.74
1961	3,705,849	113,338	513,865	4.53	1,603,464	2,888,592	1.80
1962	2,580,884	458,122	249,330	0.54	1,748,178	4,951,714	2.83
1963	338,760	64,377	94,415	1.47	23,377	918,394	39.29
1964	957,120	252,384	2,447,045	9.70	222,528	2,918,799	13.12
1965	24,325,926	2,866,214	10,090,601	3.52	5,475,362	32,942,281	6.02
1966	3,775,184	648,321	1,534,238	2.37	541,017	4,488,399	8.30
1967	3,216,208	594,327	572,694	0.96	298,282	829,337	2.78
1968	2,557,440	185,356	300,402	1.62	-		
Estimates of smolt numbers based upon sonar equipment							
1968	2,557,440	-			5,959,383	206,095	0.03
1969	8,394,204	85,723,430	442,515	0.01	54,159,340	4,787,896	0.09
1970	13,935,306	464,219	55,624	0.12	191,842,930	15,152,302	0.08
1971	2,387,392	5,123,400	332,822	0.06	21,423,246	2,412,403	0.11

-Continued-

Table 7. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1952-1982 brood years, Kvichak River, Bristol Bay, Alaska. A dash (-) indicates data not available (continued).

Brood Year	Total Spawning Escapement	Age I			Age II		
		Number of Smolt	Adult Returns	Adult Returns per Smolt	Number of Smolt	Adult Returns	Adult Returns per Smolt
		Estimates of smolt numbers based upon sonar equipment (continued)					
1972	1,009,962	2,740,610	404,693	0.15	-	1,468,546	0.25
1973	226,554	-	1,566,472	0.16	3,031,287	802,035	0.26
1974	4,433,844	108,356,892	8,158,273	0.08	114,269,848	17,127,032	0.15
1975	13,140,450	78,308,251	6,735,383	0.09	213,364,470	28,823,894	0.14
1976	1,965,282	32,226,544	5,847,020	0.18	26,423,348	4,012,457	0.15
1977	1,341,144	28,758,191	2,451,387	0.09	10,410,467	281,173	0.03
1978	4,149,288	182,442,540	2,702,719	0.01 a/	32,294,536	1,232,894	0.04 a/
1979	11,218,434	219,928,232	17,484,500	0.08 a/	89,300,703		
1980	22,505,268	150,421,026			76,244,773		
1981	1,754,358	6,549,125					

a/ Future adult returns will increase these values.

Table 8. Climatological and hydrological observations made at sockeye salmon smolt counting site, Kvichak River, Bristol Bay, Alaska, 1983. A dash (-) indicates missing data.

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp. (C)		Mean Water Temp. (C)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr	Min	Max		
5 19	1	1	- -	25 SW	-	-	5.2	clear
5 20	1	3	calm	25 S	6.0	28.5	5.5	clear
5 21	4	4	17 S	calm	4.0	26.0	5.6	clear
5 22	4	3	calm	5 NE	4.5	23.0	6.0	clear
5 23	3	3	33 NE	25 NE	2.0	20.0	6.8	murky
5 24	2	2	17 NE	8 NE	7.0	20.0	6.5	clear
5 25	5	3	17 S	8 SW	10.0	20.0	7.5	clear
5 26	2	1	25 NE	33 NE	12.0	21.0	8.0	clear
5 27	2	2	8 NE	8 NE	7.0	22.0	7.0	clear
5 28	3	1	17 NE	17 NE	14.0	28.0	7.5	clear
5 29	4	3	25 NE	42 NE	5.0	23.0	8.0	clear
5 30	2	4	25 SE	- -	6.0	26.0	7.0	light brown
5 31	4	4	33 NE	calm	-	-	6.0	clear
6 1	3	3	25 NE	17 NE	5.0	21.0	6.4	clear
6 2	4	4	25 SW	25 S	7.0	21.0	7.0	clear
6 3	4	4	8 SW	8 NE	4.0	27.0	8.0	clear
6 4	4	4	8 NE	8 NE	5.0	21.0	9.0	clear
6 5	3	1	8 SW	25 SW	3.0	25.0	9.6	clear
6 6	3	1	8 SW	8 N	5.5	30.0	9.5	clear
6 7	1	1	5 SW	8 NE	6.0	31.0	9.7	clear
6 8	1	1	8 NE	42 NE	7.0	31.0	9.8	clear
6 9	1	1	33 NE	17 NE	6.5	31.0	10.5	clear

-Continued-

Table 8. Climatological and hydrological observations made at sockeye salmon smolt counting site, Kvichak River, Bristol Bay, Alaska, 1983. A dash (-) indicates missing data (continued).

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp. (C)		Mean Water Temp. (C)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr	Min	Max		
6 10	1	2	17 W	8 NE	6.0	27.0	10.0	clear
6 11	1	3	8 NE	25 E	8.0	28.0	10.5	clear
6 12	4	4	33 NE	25 NE	6.0	29.0	9.8	dark brown
6 13	2	3	33 NE	17 NE	8.0	25.0	10.0	light brown
6 14	3	0	17 NE		4.0	32.0	-	clear

a/ 1 = cloud cover not more than 1/10
2 = cloud cover not more than 1/2
3 = cloud cover more than 1/2
4 = completely overcast
5 = fog

Table 9. Water temperatures at sockeye salmon smolt counting site, Kvichak River, Bristol Bay, Alaska, 1963-1983.

Year	Sample Period	Water Temperature (C) Minimum	Maximum	Mean	References
1963	16 May-14 June	2.2	8.9	5.5	Marriott (1965)
1964	18 May-14 June	0.0	5.6	2.6	Pennoyer and Seibel (1965)
1965	17 May-11 June	0.0	8.9	4.4	Pennoyer (1966)
1966	16 May-26 June	0.0	11.1	4.7	Pennoyer and Stewart (1967)
1967	17 May-20 June	1.1	9.4	6.9	Pennoyer and Stewart (1969)
1968	12 May-12 June	3.3	8.3	5.4	Paulus and McCurdy (1969)
1969	16 May-18 June	0.3	7.8	3.9	McCurdy and Paulus (1972)
1970	13 May- 7 June	2.8	11.1	6.8	Paulus and McCurdy (1972)
1971	17 May-20 June	1.1	3.3	2.4	Russell (1972)
1972	18 May-18 June	0.6	5.0	2.9	Parker (1974a)
1973	15 May-14 June	2.9	8.9	4.9	Parker (1974b)
1974	13 May- 9 June	3.0	8.0	6.2	Krasnowski (1975)
1975	17 May-15 June	2.0	8.0	3.8	Randall (1976)
1976	18 May-19 June	2.0	9.5	3.9	Randall (1977)
1977	17 May-14 June	3.0	9.5	6.4	Randall (1978)
1978	19 May- 9 June	5.0	11.0	7.6	Yuen (1980a)
1979	1-10 June	8.0	10.0	8.6	Yuen (1980b)
1980	16 May-18 June	1.5	9.0	5.5	Bergstrom and Yuen (1981)
1981	15 May- 9 June	7.0	10.0	8.2	Yuen and Wise (1984)
1982	14 May-15 June	2.5	8.5	4.9	Bill (1984)
	Mean	2.9	8.6	5.3	
1983	19 May-14 June	5.2	10.5	7.9	

APPENDIX A

APPENDIX A

Smolt abundance estimates for 1972-1982 have been recalculated (Appendix Tables 1-10) using adjustments for deviations of mean smolt weight from the pre-1971 mean of 8.3 g as follows:

$$S_i = 10\ (8.3\ g\ /\ W_i)\ ,\ \text{where}$$

S_i = smolt per sonar count for year i, and W_i = actual mean smolt weight for year i. Daily adjustments for variation of mean smolt weight were not made prior to 1983. The following summary shows types and sources of data used in final calculations:

Year	Data Source	Daily Age Comp.	Daily Weight	Daily Sonar Counts	Water Velocity Over Array	Smolt Distr. Across River	Water Depth Over Array
1972	Parker 1974a	Table 6	Pg 34 a/	Table 14	Table 12	b/	c/
1973	Parker 1974b	Table 7	Pg 5 a/	Table 6	d/	b/	c/
1974	Krasnowski 1975	Table 6	Pg 5	Table 5	d/	b/	c/
1975	No data available, sonar gear damaged by ice						
1976	Randall 1977	Table 5 f/	Pg 3 a/	e/	Pg 4	Fig 1	c/
1977	Randall 1978	Table 3 f/	Pg 4 a/	Table 2	Pg 3	Fig 2	c/
1978	Yuen 1980a	Table 2	Table 4	Table 1	Pg 2	Fig 2	Table 6
1979	Yuen 1980b	Table 3	Table 5	Table 2	Pg 2	Fig 1	Table 1
1980	Bergstrom & Yuen 1981	Table 3	Table 6	Table 2	Pg 3	Fig 1	Table 1
1981	Yuen & Wise 1982	Table 3	Table 6	Table 2	Pg 3	Fig 1	Table 6
1982	Bill 1984	Table 3	Table 5	Table 2	Pg 3	g/	h/

a/ No daily weights by age group available, used mean weight by age group.
b/ Assumed uniform smolt distribution across river.
c/ Assumed water depth sufficient for array transducer beams to cover 4.72 m (12 ft).

d/ No change to original water velocity adjustments.
e/ Sonar counts by array not given by Randall (1977), daily sonar counts obtained from original data forms.
f/ Used age composition by sample period from Randall (1978).
g/ Distances from river bank to start of smolt distribution, inshore, center and offshore arrays, and to end of smolt distribution across river were 12.2, 28.2, 41.4, 60.0 and 77.7 m (40.0, 92.5, 135.8, 197.0 and 255.0 ft), respectively.
h/ Water depth was 2.24 m (7.35 ft).

Appendix A.1. Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska 1972.

Date a/	Age I			Age II			All Ages	
	Cumulative			Cumulative				
	Number	Percent	Total	Number	Percent	Total	Daily Total	Cumulative Total
5 29	268	1.53	268	17,255	98.47	17,255	17,523	17,523
5 30	418	1.53	686	26,959	98.47	44,214	27,378	44,901
5 31	6,687	1.53	7,374	430,389	98.47	474,604	437,076	481,978
6 1	1,227	1.53	8,601	78,971	98.47	553,576	80,199	562,177
6 2	509	1.53	9,110	32,796	98.47	586,373	33,306	595,484
6 3	1,483	1.53	10,594	95,486	98.47	681,859	96,970	692,454
6 4	2,718	1.53	13,313	174,985	98.47	856,845	177,704	870,158
6 5	1,150	0.53	14,464	216,000	99.47	1,072,846	217,151	1,087,310
6 6	2,934	0.28	17,398	1,045,076	99.72	2,117,922	1,048,010	2,135,321
6 7	9,023	0.32	26,422	2,810,836	99.68	4,928,759	2,819,860	4,955,181
6 8	31,617	1.04	58,039	3,008,526	98.96	7,937,286	3,040,144	7,995,326
6 9	5,573	0.30	63,613	1,852,381	99.70	9,789,667	1,857,955	9,853,281
6 10	41,016	0.44	104,629	9,280,856	99.56	19,070,524	9,321,872	19,175,154
6 11	0	0.00	104,629	2,100,895	100.00	21,171,420	2,100,895	21,276,050
6 12	141,851	1.92	246,481	7,246,252	98.08	28,417,672	7,388,103	28,664,153
6 13	0	0.00	246,481	5,646,641	100.00	34,064,313	5,646,641	34,310,795
6 14	66,875	1.06	313,356	6,242,104	98.94	40,306,418	6,308,979	40,619,774
6 15	0	0.00	313,356	4,463,763	100.00	44,770,181	4,463,763	45,083,538
6 16	0	0.00	313,356	2,428,190	100.00	47,198,371	2,428,190	47,511,728
6 17	118,248	2.32	431,605	4,978,679	97.68	52,177,051	5,096,928	52,608,656
6 18	8,664	1.54	440,270	553,984	98.46	52,731,035	562,649	53,171,306
6 19	1,829	1.54	442,099	116,959	98.46	52,847,995	118,788	53,290,094
6 20	2,772	1.54	444,872	177,282	98.46	53,025,277	180,054	53,470,149
6 21	3,124	1.54	447,997	199,772	98.46	53,225,049	202,897	53,673,046

-Continued-

Appendix A.1. Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska 1972. (Continued)

Date a/	Age I			Age II			All Ages	
	Cumulative			Cumulative				
	Number	Percent	Total	Number	Percent	Total	Daily Total	Cumulative Total
6 22	121	1.54	448,118	7,740	98.46	53,232,789	7,861	53,680,908
6 23	1,685	1.54	449,803	107,756	98.46	53,340,546	109,441	53,790,349
6 24	6,144	1.54	455,947	392,842	98.46	53,733,388	398,986	54,189,336
6 25	2,289	1.54	458,236	146,348	98.46	53,879,737	148,637	54,337,974
6 26	661	0.76	458,898	86,362	99.24	53,966,100	87,024	54,424,998
6 27	2,890	2.68	461,788	104,948	97.32	54,071,048	107,838	54,532,836
6 28	2,431	2.68	464,219	88,292	97.32	54,159,340	90,723	54,623,560

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Appendix A.2. Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska 1973.

Date	a/	Age I			Age II			All Ages	
		Cumulative			Cumulative				
		Number	Percent	Total	Number	Percent	Total	Daily Total	Cumulative Total
5	21	0	0.00	0	1,364,219	100.00	1,364,219	1,364,219	1,364,219
5	22	0	0.00	0	9,878,646	100.00	11,242,866	9,878,646	11,242,866
5	23	111,647	0.50	111,647	22,217,950	99.50	33,460,816	22,329,598	33,572,464
5	24	775,923	1.60	887,571	47,719,268	98.40	81,180,085	48,495,191	82,067,656
5	25	0	0.00	887,571	17,498,563	100.00	98,678,648	17,498,563	99,566,219
5	26	47,260	0.90	934,831	5,203,953	99.10	103,882,601	5,251,213	104,817,433
5	27	1,148,910	2.70	2,083,742	41,403,335	97.30	145,285,936	42,552,245	147,369,678
5	28	1,430,168	9.60	3,513,910	13,467,418	90.40	158,753,355	14,897,587	162,267,265
5	29	22,942	1.30	3,536,853	1,741,861	98.70	160,495,216	1,764,804	164,032,070
5	30	37,947	1.50	3,574,800	2,491,877	98.50	162,987,094	2,529,825	166,561,895
5	31	725,653	5.70	4,300,454	12,005,112	94.30	174,992,207	12,730,766	179,292,661
6	1	50,206	5.60	4,350,660	846,339	94.40	175,838,546	896,546	180,189,207
6	2	0	0.00	4,350,660	740,586	100.00	176,579,133	740,586	180,929,794
6	3	0	0.00	4,350,660	3,173,826	100.00	179,752,959	3,173,826	184,103,620
6	4	84,881	3.70	4,435,542	2,209,225	96.30	181,962,185	2,294,107	186,397,728
6	5	317,274	11.00	4,752,816	2,567,035	89.00	184,529,220	2,884,309	189,282,037
6	6	60,618	3.60	4,813,434	1,623,215	96.40	186,152,435	1,683,833	190,965,870
6	7	0	0.00	4,813,434	2,546,576	100.00	188,699,012	2,546,576	193,512,446
6	8	109,844	7.00	4,923,279	1,459,365	93.00	190,158,377	1,569,209	195,081,656
6	9	44,744	7.20	4,968,024	576,711	92.80	190,735,088	621,456	195,703,113
6	10	71,219	12.30	5,039,244	507,803	87.70	191,242,892	579,023	196,282,136
6	11	52,411	12.30	5,091,656	373,700	87.70	191,616,592	426,112	196,708,248
6	12	31,744	12.30	5,123,400	226,338	87.70	191,842,930	258,082	196,966,331

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Appendix A.3. Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska 1974.

	Age I			Age II			Age III			All Ages	
	Cumulative			Cumulative			Cumulative				
Date a/	Number	Percent	Total	Number	Percent	Total	Number	Percent	Total	Daily Total	Cumulative Total
5 19	0	0.00	0	127,161	80.20	127,161	31,393	19.80	31,393	158,554	158,554
5 20	7,149	1.80	7,149	261,763	65.90	388,924	128,299	32.30	159,693	397,212	555,767
5 21	0	0.00	7,149	343,271	72.30	732,195	131,516	27.70	291,209	474,787	1,030,554
5 22	11,445	0.80	18,595	1,214,671	84.90	1,946,866	204,591	14.30	495,800	1,430,708	2,461,263
5 23	0	0.00	18,595	898,227	87.10	2,845,094	133,032	12.90	628,833	1,031,259	3,492,523
5 24	52,695	5.80	71,291	821,328	90.40	3,666,423	34,524	3.80	663,358	908,549	4,401,072
5 25	50,982	1.50	122,274	3,198,323	94.10	6,864,746	149,549	4.40	812,908	3,398,856	7,799,928
5 26	369,006	10.20	491,280	3,035,258	83.90	9,900,004	213,444	5.90	1,026,352	3,617,709	11,417,638
5 27	0	0.00	491,280	1,225,903	52.20	11,125,908	1,122,570	47.80	2,148,923	2,348,474	13,766,112
5 28	106,605	6.20	597,885	1,518,263	88.30	12,644,171	94,569	5.50	2,243,492	1,719,437	15,485,550
5 29	532,845	15.90	1,130,731	2,637,419	78.70	15,281,590	180,966	5.40	2,424,459	3,351,231	18,836,781
5 30	289,483	16.30	1,420,215	1,447,417	81.50	16,729,008	39,071	2.20	2,463,530	1,775,972	20,612,753
5 31	136,358	33.30	1,556,573	253,470	61.90	16,982,479	19,655	4.80	2,483,185	409,483	21,022,237
6 1	284,094	8.50	1,840,667	2,720,618	81.40	19,703,097	337,570	10.10	2,820,756	3,342,282	24,364,520
6 2	35,658	19.80	1,876,325	123,363	68.50	19,826,460	21,070	11.70	2,841,826	180,092	24,544,612
6 3	225,016	25.30	2,101,342	609,235	68.50	20,435,695	55,142	6.20	2,896,969	889,394	25,434,007
6 4	283,900	24.60	2,385,242	860,934	74.60	21,296,629	9,232	0.80	2,906,201	1,154,067	26,588,074
6 5	295,724	79.00	2,680,967	75,615	20.20	21,372,245	2,994	0.80	2,909,196	374,335	26,962,409
6 6	22,778	56.80	2,703,746	14,838	37.00	21,387,083	2,486	6.20	2,911,683	40,103	27,002,513
6 7	22,734	56.80	2,726,480	14,809	37.00	21,401,893	2,481	6.20	2,914,164	40,025	27,042,538

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Appendix A.4. Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska 1976.

Date a/	Age I			Age II			All Ages	
	Cumulative			Cumulative				
	Number	Percent	Total	Number	Percent	Total	Daily Total	Cumulative Total
5 22	30,626	82.00	30,626	6,722	18.00	6,722	37,349	37,349
5 23	32,484	82.00	63,111	7,130	18.00	13,853	39,615	76,964
5 24	184,723	82.00	247,835	40,549	18.00	54,402	225,273	302,237
5 25	66,290	82.00	314,125	14,551	18.00	68,954	80,841	383,079
5 26	73,187	82.00	387,312	16,065	18.00	85,019	89,252	472,332
5 27	205,811	100.00	593,124	0	0.00	85,019	205,811	678,143
5 28	107,446	100.00	700,570	0	0.00	85,019	107,446	785,589
5 29	112,092	100.00	812,662	0	0.00	85,019	112,092	897,682
5 30	166,578	100.00	979,240	0	0.00	85,019	166,578	1,064,260
5 31	299,255	100.00	1,278,496	0	0.00	85,019	299,255	1,363,516
6 1	213,570	99.00	1,492,066	2,157	1.00	87,177	215,727	1,579,243
6 2	236,634	99.00	1,728,701	2,390	1.00	89,567	239,024	1,818,268
6 3	296,453	99.00	2,025,154	2,994	1.00	92,561	299,447	2,117,716
6 4	574,032	99.00	2,599,187	5,798	1.00	98,360	579,830	2,697,547
6 5	393,331	99.00	2,992,518	3,973	1.00	102,333	397,304	3,094,851
6 6	188,597	94.00	3,181,115	12,038	6.00	114,371	200,635	3,295,486
6 7	547,533	94.00	3,728,648	34,948	6.00	149,320	582,482	3,877,968
6 8	3,263,477	94.00	6,992,126	208,307	6.00	357,627	3,471,785	7,349,753
6 9	14,824,339	94.00	21,816,466	946,234	6.00	1,303,861	15,770,574	23,120,328
6 10	26,637,069	94.00	48,453,535	1,700,238	6.00	3,004,100	28,337,308	51,457,636
6 11	15,879,058	100.00	64,332,594	0	0.00	3,004,100	15,879,058	67,336,694
6 12	20,315,595	100.00	84,648,189	0	0.00	3,004,100	20,315,595	87,652,289
6 13	17,443,200	100.00	102,091,389	0	0.00	3,004,100	17,443,200	105,095,490
6 14	2,508,010	100.00	104,599,400	0	0.00	3,004,100	2,508,010	107,603,500
6 15	1,065,905	100.00	105,665,306	0	0.00	3,004,100	1,065,905	108,669,406
6 16	1,687,752	99.00	107,353,059	17,048	1.00	3,021,148	1,704,800	110,374,207
6 17	1,003,833	99.00	108,356,892	10,139	1.00	3,031,287	1,013,973	111,388,180

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Appendix A.5. Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska 1977.

Date	a/	Age I			Age II			All Ages	
		Cumulative			Cumulative				
		Number	Percent	Total	Number	Percent	Total	Daily Total	Cumulative Total
5	20	21,234	6.40	21,234	310,554	93.60	310,554	331,789	331,789
5	21	33,866	6.40	55,101	495,300	93.60	805,855	529,167	860,956
5	22	49,340	6.40	104,441	721,598	93.60	1,527,453	770,938	1,631,895
5	23	591,674	6.40	696,115	8,653,238	93.60	10,180,691	9,244,912	10,876,807
5	24	264,812	6.40	960,928	3,872,885	93.60	14,053,577	4,137,698	15,014,506
5	25	230,038	6.40	1,190,966	3,364,309	93.60	17,417,887	3,594,348	18,608,854
5	26	1,432,727	27.90	2,623,694	3,702,495	72.10	21,120,383	5,135,223	23,744,077
5	27	2,035,223	27.90	4,658,917	5,259,485	72.10	26,379,868	7,294,708	31,038,786
5	28	4,957,382	27.90	9,616,300	12,811,014	72.10	39,190,882	17,768,396	48,807,183
5	29	6,643,605	27.90	16,259,905	17,168,600	72.10	56,359,483	23,812,205	72,619,388
5	30	1,619,018	27.90	17,878,924	4,183,914	72.10	60,543,397	5,802,932	78,422,321
5	31	4,693,762	34.30	22,572,686	8,990,675	65.70	69,534,072	13,684,437	92,106,759
6	1	5,489,439	34.30	28,062,126	10,514,757	65.70	80,048,829	16,004,196	108,110,955
6	2	3,673,410	34.30	31,735,536	7,036,239	65.70	87,085,069	10,709,650	118,820,605
6	3	1,605,669	34.30	33,341,205	3,075,582	65.70	90,160,652	4,681,251	123,501,857
6	4	2,966,514	34.30	36,307,720	5,682,214	65.70	95,842,867	8,648,729	132,150,587
6	5	3,015,603	34.30	39,323,323	5,776,242	65.70	101,619,109	8,791,845	140,942,432
6	6	10,351,458	75.50	49,674,781	3,359,082	24.50	104,978,191	13,710,540	154,652,973
6	7	5,047,868	75.50	54,722,649	1,638,050	24.50	106,616,242	6,685,918	161,338,892
6	8	3,325,467	75.50	58,048,117	1,079,125	24.50	107,695,367	4,404,593	165,743,485
6	9	4,700,374	75.50	62,748,492	1,525,287	24.50	109,220,654	6,225,662	171,969,147
6	10	6,209,754	75.50	68,958,247	2,015,086	24.50	111,235,740	8,224,840	180,193,988
6	11	4,674,030	75.50	73,632,277	1,516,738	24.50	112,752,479	6,190,768	186,384,756
6	12	2,433,134	75.50	76,065,412	789,560	24.50	113,542,039	3,222,695	189,607,451
6	13	2,242,839	75.50	78,308,251	727,808	24.50	114,269,848	2,970,647	192,578,099

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Appendix A.6. Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska 1978.

Date	a/	Age I			Age II			All Ages	
		Cumulative			Cumulative				
		Number	Percent	Total	Number	Percent	Total	Daily Total	Cumulative Total
5	18	1,411,447	11.54	1,411,447	10,816,009	88.46	10,816,009	12,227,456	12,227,456
5	19	894,878	11.54	2,306,326	6,857,512	88.46	17,673,522	7,752,391	19,979,848
5	20	446,752	11.54	2,753,079	3,423,493	88.46	21,097,015	3,870,245	23,850,094
5	21	3,203,004	11.54	5,956,083	24,544,824	88.46	45,641,839	27,747,828	51,597,923
5	22	3,245,972	11.54	9,202,056	24,874,086	88.46	70,515,926	28,120,058	79,717,982
5	23	3,314,818	11.54	12,516,874	25,401,660	88.46	95,917,586	28,716,479	108,434,461
5	24	4,913,714	11.54	17,430,589	37,654,098	88.46	133,571,685	42,567,813	151,002,274
5	25	3,480,972	11.54	20,911,561	26,674,908	88.46	160,246,594	30,155,881	181,158,155
5	26	2,345,819	11.54	23,257,380	17,976,156	88.46	178,222,750	20,321,975	201,480,131
5	27	548,374	11.54	23,805,754	4,202,224	88.46	182,424,975	4,750,598	206,230,730
5	28	261,372	11.54	24,067,127	2,002,911	88.46	184,427,887	2,264,283	208,495,014
5	29	1,953,609	11.54	26,020,736	14,970,627	88.46	199,398,514	16,924,236	225,419,251
5	30	2,892,198	30.76	28,912,934	6,508,792	69.24	205,907,307	9,400,991	234,820,242
5	31	1,406,534	30.76	30,319,469	3,165,357	69.24	209,072,664	4,571,891	239,392,133
6	1	1,026,214	30.76	31,345,683	2,309,460	69.24	211,382,124	3,335,674	242,727,808
6	2	161,963	30.76	31,507,647	364,494	69.24	211,746,618	526,458	243,254,266
6	3	277,175	30.76	31,784,823	623,774	69.24	212,370,393	900,950	244,155,217
6	4	60,040	30.76	31,844,863	135,118	69.24	212,505,511	195,158	244,350,375
6	5	199,657	30.76	32,044,521	449,322	69.24	212,954,834	648,980	244,999,356
6	6	58,372	30.76	32,102,893	131,364	69.24	213,086,199	189,736	245,189,093
6	7	67,983	30.76	32,170,877	152,994	69.24	213,239,193	220,977	245,410,070
6	8	32,227	30.76	32,203,105	72,527	69.24	213,311,721	104,755	245,514,826
6	9	23,439	30.76	32,226,544	52,749	69.24	213,364,470	76,188	245,591,014

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Appendix A.7. Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska 1979.

Date		Age I			Age II			All Ages	
		Cumulative			Cumulative				
	a/	Number	Percent	Total	Number	Percent	Total	Daily Total	Cumulative Total
5	16	68,179	34.57	68,179	129,026	65.43	129,026	197,205	197,205
5	17	395,222	34.57	463,401	747,947	65.43	876,974	1,143,169	1,340,375
5	18	58,521	34.57	521,922	110,749	65.43	987,723	169,270	1,509,645
5	19	325,243	34.57	847,165	615,514	65.43	1,603,237	940,757	2,450,403
5	20	62,596	34.57	909,762	118,461	65.43	1,721,699	181,058	2,631,462
5	21	1,250,354	34.57	2,160,117	2,366,261	65.43	4,087,961	3,616,616	6,248,078
5	22	1,056,603	34.57	3,216,721	1,999,593	65.43	6,087,555	3,056,197	9,304,276
5	23	331,110	34.57	3,547,831	626,618	65.43	6,714,173	957,728	10,262,005
5	24	2,474,832	34.57	6,022,664	4,683,552	65.43	11,397,725	7,158,384	17,420,390
5	25	3,021,168	34.57	9,043,832	5,717,477	65.43	17,115,203	8,738,645	26,159,035
5	26	2,336,353	34.57	11,380,185	4,421,483	65.43	21,536,687	6,757,837	32,916,872
5	27	657,363	34.57	12,037,549	1,244,042	65.43	22,780,729	1,901,405	34,818,278
5	28	3,647,891	83.21	15,685,440	735,874	16.79	23,516,604	4,383,766	39,202,044
5	29	722,077	83.21	16,407,518	145,661	16.79	23,662,266	867,739	40,069,784
5	30	3,726,437	83.21	20,133,955	751,719	16.79	24,413,985	4,478,156	44,547,940
5	31	2,026,758	83.21	22,160,713	408,850	16.79	24,822,835	2,435,608	46,983,549
6	1	1,102,606	83.21	23,263,320	222,424	16.79	25,045,260	1,325,030	48,308,580
6	2	203,791	83.21	23,467,111	41,110	16.79	25,086,370	244,901	48,553,482
6	3	456,589	83.21	23,923,701	92,105	16.79	25,178,476	548,695	49,102,177
6	4	1,461,840	83.21	25,385,541	294,891	16.79	25,473,367	1,756,731	50,858,909
6	5	1,347,593	83.21	26,733,134	271,844	16.79	25,745,212	1,619,438	52,478,347
6	6	507,405	83.21	27,240,539	102,356	16.79	25,847,569	609,762	53,088,109
6	7	613,461	83.21	27,854,000	123,751	16.79	25,971,320	737,212	53,825,321
6	8	377,802	66.67	28,231,803	188,873	33.33	26,160,193	566,675	54,391,997
6	9	106,211	66.67	28,338,014	53,097	33.33	26,213,291	159,308	54,551,305
6	10	420,177	66.67	28,758,191	210,057	33.33	26,423,348	630,234	55,181,540

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Appendix A.8. Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska 1980.

Date		Age I			Age II			All Ages	
		Cumulative			Cumulative				
	a/	Number	Percent	Total	Number	Percent	Total	Daily Total	Cumulative Total
5	15	262,996	89.80	262,996	29,861	10.20	29,861	292,858	292,858
5	16	162,466	89.80	425,463	18,447	10.20	48,309	180,914	473,772
5	17	128,383	89.80	553,847	14,577	10.20	62,886	142,960	616,733
5	18	202,329	89.80	756,177	22,973	10.20	85,859	225,303	842,036
5	19	986,574	89.80	1,742,751	112,019	10.20	197,879	1,098,594	1,940,631
5	20	217,457	89.80	1,960,208	24,691	10.20	222,570	242,148	2,182,779
5	21	2,324,309	89.80	4,284,518	263,912	10.20	486,483	2,588,221	4,771,001
5	22	15,780,526	89.80	20,065,044	1,791,790	10.20	2,278,273	17,572,316	22,343,317
5	23	5,850,351	89.80	25,915,395	664,274	10.20	2,942,547	6,514,626	28,857,943
5	24	4,675,265	89.80	30,590,661	530,850	10.20	3,473,398	5,206,115	34,064,059
5	25	6,570,170	89.80	37,160,831	746,005	10.20	4,219,404	7,316,176	41,380,235
5	26	13,467,276	89.80	50,628,108	1,529,133	10.20	5,748,537	14,996,410	56,376,645
5	27	28,899,727	95.62	79,527,835	1,322,209	4.37	7,070,747	30,221,936	86,598,582
5	28	26,289,850	95.62	105,817,685	1,202,803	4.37	8,273,550	27,492,654	114,091,236
5	29	7,948,090	95.62	113,765,776	363,638	4.37	8,637,189	8,311,728	122,402,965
5	30	919,229	95.62	114,685,005	42,056	4.37	8,679,245	961,285	123,364,251
5	31	1,344,577	97.06	116,029,583	40,675	2.94	8,719,921	1,385,253	124,749,504
6	1	20,511,647	97.06	136,541,230	620,512	2.94	9,340,433	21,132,159	145,881,663
6	2	2,785,842	97.06	139,327,073	84,276	2.94	9,424,709	2,870,118	148,751,782
6	3	3,849,582	97.06	143,176,655	116,456	2.94	9,541,165	3,966,038	152,717,821
6	4	3,961,266	97.06	147,137,922	119,835	2.94	9,661,000	4,081,101	156,798,923
6	5	2,094,031	97.33	149,231,954	57,412	2.67	9,718,413	2,151,444	158,950,367
6	6	930,065	97.33	150,162,019	25,499	2.67	9,743,913	955,565	159,905,932
6	7	1,326,524	97.33	151,488,543	36,369	2.67	9,780,283	1,362,894	161,268,827
6	8	1,425,267	97.33	152,913,811	39,077	2.67	9,819,360	1,464,344	162,733,172
6	9	3,223,929	97.33	156,137,740	88,391	2.67	9,907,752	3,312,321	166,045,493

-Continued-

Appendix A.8. Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska 1980 (continued).

Date		Age I			Age II			All Ages	
		Cumulative			Cumulative				
	a/	Number	Percent	Total	Number	Percent	Total	Daily Total	Cumulative Total
6	10	5,725,521	97.33	161,863,262	156,978	2.67	10,064,730	5,882,500	171,927,993
6	11	2,052,994	97.33	163,916,257	56,287	2.67	10,121,018	2,109,282	174,037,276
6	12	3,570,730	98.46	167,486,987	55,787	1.54	10,176,806	3,626,518	177,663,794
6	13	3,638,967	98.46	171,125,955	56,854	1.54	10,233,660	3,695,821	181,359,616
6	14	3,556,613	98.46	174,682,568	55,567	1.54	10,289,228	3,612,180	184,971,796
6	15	3,786,325	98.46	178,468,894	59,156	1.54	10,348,384	3,845,482	188,817,279
6	16	2,590,446	98.46	181,059,341	40,472	1.54	10,388,856	2,630,918	191,448,198
6	17	1,383,199	98.46	182,442,540	21,610	1.54	10,410,467	1,404,809	192,853,007

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Appendix A.9. Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska 1981.

Date		Age I			Age II			All Ages	
		Cumulative			Cumulative				
	a/	Number	Percent	Total	Number	Percent	Total	Daily Total	Cumulative Total
5	13	2,464,338	80.56	2,464,338	594,581	19.44	594,581	3,058,919	3,058,919
5	14	804,834	80.56	3,269,172	194,185	19.44	788,766	999,019	4,057,939
5	15	2,026,386	80.56	5,295,559	488,914	19.44	1,277,681	2,515,301	6,573,240
5	16	1,648,355	80.56	6,943,914	397,705	19.44	1,675,386	2,046,061	8,619,301
5	17	3,734,453	80.56	10,678,367	901,026	19.44	2,576,413	4,635,480	13,254,781
5	18	3,571,918	80.56	14,250,286	861,811	19.44	3,438,224	4,433,729	17,688,511
5	19	1,087,943	80.56	15,338,229	262,492	19.44	3,700,717	1,350,435	19,038,947
5	20	709,533	80.56	16,047,763	171,192	19.44	3,871,909	880,725	19,919,672
5	21	1,613,044	80.56	17,660,807	389,185	19.44	4,261,095	2,002,229	21,921,902
5	22	4,351,379	80.56	22,012,187	1,049,875	19.44	5,310,970	5,401,255	27,323,157
5	23	36,813,000	80.56	58,825,187	8,882,023	19.44	14,192,993	45,695,023	73,018,180
5	24	35,941,453	92.19	94,766,640	3,045,885	7.81	17,238,879	38,987,338	112,005,519
5	25	31,154,575	92.19	125,921,215	2,640,217	7.81	19,879,097	33,794,793	145,800,312
5	26	19,280,692	92.19	145,201,908	1,633,956	7.81	21,513,053	20,914,649	166,714,962
5	27	13,212,031	92.19	158,413,939	1,119,663	7.81	22,632,717	14,331,695	181,046,657
5	28	13,065,661	82.91	171,479,601	2,692,712	17.09	25,325,429	15,758,374	196,805,031
5	29	7,092,114	82.91	178,571,716	1,461,619	17.09	26,787,048	8,553,733	205,358,765
5	30	8,681,831	82.91	187,253,548	1,789,245	17.09	28,576,294	10,471,077	215,829,842
5	31	8,227,066	82.91	195,480,614	1,695,522	17.09	30,271,816	9,922,588	225,752,431
6	1	5,708,771	91.33	201,189,385	542,104	8.67	30,813,921	6,250,875	232,003,307
6	2	11,232,835	91.33	212,422,221	1,066,669	8.67	31,880,590	12,299,504	244,302,811
6	3	2,575,556	91.33	214,997,777	244,574	8.67	32,125,164	2,820,130	247,122,942
6	4	1,169,206	91.33	216,166,983	111,027	8.67	32,236,192	1,280,233	248,403,176
6	5	1,349,482	98.47	217,516,466	20,933	1.53	32,257,125	1,370,416	249,773,592
6	6	825,138	98.47	218,341,604	12,799	1.53	32,269,925	837,937	250,611,529
6	7	966,638	98.47	219,308,243	14,994	1.53	32,284,919	981,633	251,593,162
6	8	619,989	98.47	219,928,232	9,617	1.53	32,294,536	629,606	252,222,769

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Appendix A.10. Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska 1982.

Date	a/	Age I			Age II			All Ages	
		Cumulative			Cumulative				
		Number	Percent	Total	Number	Percent	Total	Daily Total	Cumulative Total
5	17	1,004	24.60	1,004	3,078	75.40	3,078	4,082	4,082
5	18	3,713	24.60	4,717	11,383	75.40	14,461	15,096	19,179
5	19	3,939	24.60	8,657	12,079	75.40	26,541	16,019	35,198
5	20	5,295	24.60	13,952	16,233	75.40	42,775	21,528	56,727
5	21	17,967	24.60	31,920	55,086	75.40	97,861	73,054	129,781
5	22	56,968	24.60	88,888	174,653	75.40	272,514	231,621	361,402
5	23	96,702	24.60	185,591	296,471	75.40	568,986	393,174	754,577
5	24	56,150	24.60	241,742	172,147	75.40	741,133	228,298	982,875
5	25	2,503,584	24.60	2,745,326	7,675,496	75.40	8,416,630	10,179,080	11,161,956
5	26	50,675	24.60	2,796,001	155,359	75.40	8,571,989	206,034	11,367,990
5	27	897,212	24.60	3,693,213	2,750,676	75.40	11,322,666	3,647,888	15,015,879
5	28	8,244,803	24.60	11,938,017	25,276,947	75.40	36,599,614	33,521,751	48,537,631
5	29	3,234,620	24.60	15,172,637	9,916,709	75.40	46,516,323	13,151,329	61,688,960
5	30	883,319	75.28	16,055,956	290,111	24.72	46,806,434	1,173,430	62,862,390
5	31	52,056,243	75.28	68,112,199	17,096,982	24.72	63,903,416	69,153,225	132,015,616
6	1	22,659,352	75.28	90,771,552	7,442,076	24.72	71,345,492	30,101,428	162,117,045
6	2	5,045,453	75.28	95,817,005	1,657,092	24.72	73,002,585	6,702,546	168,819,591
6	3	11,638,913	75.28	107,455,919	3,822,601	24.72	76,825,187	15,461,515	184,281,107
6	4	4,003,525	75.28	111,459,444	1,314,889	24.72	78,140,077	5,318,414	189,599,521
6	5	354,916	77.78	111,814,361	101,399	22.22	78,241,476	456,315	190,055,837
6	6	475,682	77.78	112,290,043	135,902	22.22	78,377,379	611,584	190,667,422
6	7	8,432,601	77.78	120,722,644	2,409,194	22.22	80,786,573	10,841,795	201,509,217
6	8	13,451,438	77.78	134,174,082	3,843,075	22.22	84,629,648	17,294,513	218,803,731
6	9	1,412,709	77.78	135,586,792	403,610	22.22	85,033,259	1,816,320	220,620,051
6	10	1,248,830	77.78	136,835,622	356,790	22.22	85,390,050	1,605,621	222,225,672
6	11	9,426,032	77.78	146,261,654	2,693,017	22.22	88,083,067	12,119,049	234,344,722

-Continued-

Appendix A.10. Daily number of sockeye smolt migrating seaward, estimated with a sonar unit, Kvichak River, Bristol Bay, Alaska 1982. (Continued)

		Age I			Age II			All Ages	
		Cumulative			Cumulative				
Date	a/	Number	Percent	Total	Number	Percent	Total	Daily Total	Cumulative Total
6	12	3,537,344	77.78	149,798,999	1,010,619	22.22	89,093,686	4,547,964	238,892,686
6	13	246,333	77.78	150,045,333	70,377	22.22	89,164,064	316,711	239,209,397
6	14	375,693	73.33	150,421,026	136,638	26.67	89,300,703	512,331	239,721,729

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

NAKNEK, EGEGIK, AND UGASHIK RIVERS SOCKEYE SALMON SMOLT STUDIES FOR 1983

By

Stephen M. Fried, Henry J. Yuen, and Brian G. Bue
Alaska Department of Fish and Game
Division of Commercial Fisheries
Anchorage, Alaska

INTRODUCTION

Programs to sample and count seaward migrating sockeye salmon *(Oncorhynchus nerka)* smolt provide data which are used to forecast adult returns and estimate optimal spawning escapement levels. Initial data were collected by the United States Fish and Wildlife Service (USFWS) using fyke nets. Such studies were done on the Ugashik River system during 1955-1962 (with University of Washington, Fisheries Research Institute, personnel conducting Ugashik River smolt studies in 1956 and 1957), and on the Naknek River system during 1956-1965. The Alaska Department of Fish and Game (ADF&G) assumed responsibility for Bristol Bay sockeye salmon smolt studies during the 1960s and continued using fyke nets on the Ugashik River during 1963-1965, 1967-1970, and 1972-1975, and on the Naknek River during 1966-1977.

Fyke net fishing, however, proved to be a poor method for estimating smolt numbers. Net avoidance could not be quantified and large numbers of smolt were killed during capture and handling. Therefore, field testing of sonar equipment, developed by Bendix Corporation under a contract to ADF&G, to count smolt was begun in 1970 on the Kvichak River (McCurdy 1972; Paulus and McCurdy 1972; Paulus and Parker 1974). Sonar gear was tested on the Ugashik River during 1973-1975 (Schroeder 1974 and 1975; Sanders 1976). Although results were promising, budgetary constraints limited subsequent smolt studies on this River, as well as the Naknek and Egegik Rivers, to occasional fyke net sampling to obtain age and size data (Ugashik River, 1977, 1978, and 1982; Naknek River, 1978; Egegik River, 1977 and 1978) (Huttunen 1980; Eggers 1984). An experimental, 2-array system was tested on the Egegik River during the spring of 1981 (Bue 1982) and was replaced with the present counter in 1982 (Bue 1984). Smolt sonar projects were established on the Naknek River in 1982 (Huttunen 1984), and the Ugashik River in 1983.

Objectives of the 1983 Naknek, Egegik, and Ugashik River systems sockeye salmon smolt studies were: 1) to estimate seaward migrating sockeye salmon smolt numbers, 2) to describe smolt migrations patterns, 3) to collect age, weight, and length data for smolt, and 4) to record climatological and hydrological parameters which might affect migratory behavior.

MATERIALS AND METHODS

Sonar counting equipment was used to count smolt migrating to sea past field sites on the Naknek, Egegik, and Ugashik Rivers. The equipment used consisted of either two or three 3.05-m (10-ft) ladder-shaped arrays, which were anchored underwater at the counting site, and a control unit, which was housed on shore in a canvas wall tent. Each array housed 10 upward-facing transducers and monitored about 3.35 m (11 ft) of river width. Three arrays were placed in the Naknek River, about 13 km (7.8 miles) below the outlet of Naknek Lake, and anchored 17, 39, and 67 m (56, 129, and 221 ft) from the east shore of the counting site. Three arrays were placed in the Egegik River, about 4 km (2.4 miles) below the outlet of Becharof Lake, and anchored 38, 53, and 64 m (125, 175, and 211 ft) from the west shore at the counting site. Only two arrays were placed in the Ugashik River, about 2 km (1.2 miles) below the outlet of Lower Ugashik Lake, and anchored 11 and 15 km (36 and 50 ft) from the south shore at the counting site. Installation of all sonar arrays closely followed procedures described by Randall (1977).

The control unit automatically printed counts from all arrays every hour, and could also be set to print counts at 7 1/2-, 15-, or 30-min intervals. A maximum of 19,999 counts could be accumulated by the counter before the specified printing interval was reached. If a greater number of counts was registered before this, the internal counter was set to zero and began counting from one. Therefore, the sonar system was monitored continuously throughout the season so that the number of times this occurred within each printing interval was known. Also, corrections sometimes had to be made for false counts due to drifting ice, heavy rain, wind, boat traffic, etc., and for changes in river depth or current speed.

Sonar signal pulse rate was increased as river current speed increased, since current speed determined the time required for smolt to pass through the sonar beams. Current speed measurements were obtained from a meter anchored directly behind each inshore array. Since river current speed at the Naknek and Egegik sites was affected by tide, sonar pulse rate sometimes had to be adjusted every 15 or 30 minutes. Although pulse rate could not be varied among arrays, current measurements were also made behind the other arrays to calculate correlations for current speed differences between these and the inshore array. Current speed was greatest over the inshore array at both the Naknek and Ugashik sites, but was greatest over the center array at the Egegik site (Naknek River mean speeds: inshore, 1.24 m/s [4.08 ft/s]; center, 1.15 m/s [3.80 ft/s]; offshore, 0.78 m/s [2.56 ft/s]; Egegik River mean speeds: inshore, 0.60 m/s [1.98 ft/s]; center, 0.73 m/s [2.41 ft/s]; offshore, 0.72 m/s [2.38 ft/s]; Ugashik River mean speeds: inshore, 2.31 m/s [7.62 ft/s]; offshore, 2.22 m/s [7.31 ft/s]. Therefore, Naknek River center and offshore array counts were multiplied by 0.93 and 0.63, respectively, Egegik River center and offshore counts were multiplied by 1.21 and 1.20, respectively, and Ugashik River offshore counts were multiplied by 0.96.

Total hourly counts were calculated for each array by subtracting false counts, linearly interpolating counts during missed time periods (i.e. periods when the counter was manually disabled to avoid making false counts or periods when the counter was inoperative) and multiplying these counts by a current speed correction factor. Hourly counts were then expanded to

account for smolt which migrated through sections of the river not covered by the arrays. The expansion factor used was the inverse of the estimated proportion of the total smolt migration path which was sampled by the arrays. The area of the total smolt migration path was estimated from data on 1) smolt distribution across the river at the counting site, obtained with a side scanning sonar unit, and 2) river depths across the counting site transect.

Estimates of total daily smolt migration past counting sites were made by summing adjusted total hourly counts and multiplying results by the actual number of smolt required to generate a single sonar count. All sonar systems were calibrated, at the factory, to register one count for the biomass equivalent of 41.49875 g. Therefore, pooled mean weight of all salmonid smolt from daily fyke net samples was used to estimate actual number of smolt equivalent to one sonar count (i.e. number per count = 41.49875 g / pooled mean weight).

Fyke net catches were also used to apportion daily smolt counts according to age class and salmonid species. Samples of at least 400 sockeye salmon smolt were used to estimate age class composition for each 24 hour sampling period. If this number of smolt was not captured during a 24 hour period, samples from subsequent periods were combined until a total of at least 400 smolt was obtained. Samples of 400 smolt produced estimates of the actual proportion of age I or age II smolt which were within 5% of the actual proportion (at the 0.05 significance level) for actual age class proportions ranging from 0.95 to 0.05 (Cochran 1963). Samples of this size also produced estimates of the actual number of either age I or II smolt which were within 50% of the estimated number (at the 0.05 significance level) for actual age class proportions ranging from 0.05 to 0.20, and which were within 15% of the estimated number (at the 0.05 significance level) for actual age class proportions ranging from 0.30 to 0.95.

To obtain daily age data for 400 sockeye salmon smolt, it was necessary to decrease the time needed for sampling. Therefore, scale samples, weights and fork lengths were obtained only from about 150 smolt each day. An additional 250 smolt were measured for length data, but were not weighed or used for scale samples. After the field season, smolt for which only length measurements had been obtained were assigned a weight and an age based upon analysis of available age, weight, and length data.

A 1.2-m x 1.8-m (4-ft x 6-ft) fyke net was used to capture smolt for samples. Initially, sampling was attempted at 0600, 1200, 1800, and 2400 h each day. However, few smolt were caught between 0600 and 2400 h, and all sampling effort was shifted to the period between 2400 and 0500 h.

RESULTS AND DISCUSSION

Naknek River

A total of 2,227,250 sonar counts were recorded during the 1983 season, 19 May through 5 July (Table 1). About 23% of these counts were registered over the inshore array, 42% over the center array, and 35% over the offshore

array. Most smolt migration across the counting site transect occurred from the east bank of the river to a point 73 m (240 ft) offshore.

The final sockeye salmon smolt population size estimate was 53,318,822 (Table 2). Age composition of the total population was 69% age I (1981 brood year), 31% age II (1980 brood year), and less than 0.1% age III (1979 brood year). Since age II and III smolt were usually larger and tended to migrate to sea earlier in the season than age I smolt, numbers of smolt per sonar count increased as the season progressed (range, 2.8 to 5.7 smolt per count) (Table 3).

A total of 9,480 sockeye salmon smolt were sampled for age, weight, and length information (Table 4). Mean weights of age I, II, and III smolt were 8.0, 12.2, and 19.1 g, respectively. Mean lengths of age I, II, and III smolt were 94, 110, and 133 mm, respectively. Mean sizes of age I and II smolt were less than the grand mean for past years (1957-1982: age I smolt length and weight, 100 mm and 9.1 g, respectively; age II smolt length and weight, 112 mm and 12.6 g, respectively) (Table 5).

Weather and river conditions were recorded at the sonar site during 20 May through 6 July (Table 6). Mean air and water temperatures during this period were 10.7°C (range, 0.0-23.0°C) and 12.8°C (range, 8.0-16.0°C), respectively. Mean water temperature during past seasons was generally lower than that recorded during 1983 (1967-1982: mean, 10.6°C; range, 6.8-11.0°C) (Table 7).

Egegik River

A total of 1,557,847 sonar counts were recorded during the 1983 season, 17 May through 10 June (Table 8). About 12% of these counts were registered over the inshore array, 72% over the center array, and 16% over the offshore array. Most smolt migration across the counting site transect occurred within the area 3 m to 88 m offshore of the west bank.

The final sockeye salmon smolt population size estimate was 18,766,889 (Table 9). Age composition of the total population was 12% age I (1981 brood year) and 88% age II (1980 brood year). No age III smolt were captured during fyke net fishing. Since larger, and generally older, smolt tended to migrate to sea earlier in the season than smaller smolt, numbers of smolt per sonar count increased as the season progressed (range, 2.67 to 3.96 smolt per count) (Table 10).

A total of 2,631 sockeye salmon smolt were sampled for age, weight, and length information (Table 11). Mean weights of age I and II smolt were 9.5 and 13.7 g, respectively. Mean lengths of age I and age II smolt were 101.5 and 116.7 mm, respectively. Mean sizes of age I and II smolt were less than the grand mean for past years (1969-1982: age I smolt length and weight, 103.0 mm and 9.9 g, respectively; age II smolt length and weight, 118.0 mm and 15.6 g, respectively) (Table 12).

Weather and river conditions were recorded at the sonar site intermittently during 18 May through 10 June (Table 13). Mean air and water temperatures during this period were 10.6°C (range, 3.5-27.0°C) and 7.0°C (range, 5.0-9.5°C), respectively. During peak smolt migration, 21-31 May, water temperature was 6.6°C. Water temperature during the 1983 season was warmer

than that recorded during 1982 (1982: mean, 2.9°C; peak smolt migration period, 28 May to 2 June, 3.5°C). This may have caused smolt to migrate seaward about one week earlier in 1983 than was observed in 1982.

Ugashik River

A total of 5,500,388 sonar counts were recorded during the 1983 season, 21 May through 16 June (Table 14). About 82% of these counts were registered over the inshore array and 18% over the offshore array. Most smolt migration across the counting site transect occurred from the south bank of the river to a point 90 m (297 ft) offshore.

The final sockeye salmon smolt population size estimate was 44,033,811 (Table 15). Age composition of the total population was 71% age I (1981 brood year) and 29% age II (1980 brood year). No age III smolt were captured during fyke net fishing. Additionally, a total of 2,354,233 coho salmon smolt migrated seaward during counting operations. Although age I, II, and III coho salmon smolt were present in fyke net catches, only age II smolt were abundant enough to be considered in expansion and allocation of sonar counts. (Age composition of total coho salmon smolt fyke net catch: 3% age I, 81% age II, and 15% age III). Since larger, and generally older, smolt tended to migrate to sea earlier in the season than smaller smolt, number of smolt per sonar count tended to increase as the season progressed (range, 3.22 to 6.57 smolt per count) (Table 16). An exception of this general trend was the occurrence of the greatest estimated number of smolt per count on only the second day of sampling, 22 May. This was caused by the low number of age II sockeye salmon smolt present in the fyke net catch (Table 17).

A total of 9,502 sockeye and 155 coho salmon smolt were sampled for age, weight, and length information (Tables 17 and 18). Mean weights of age I and age II sockeye salmon smolt were 7.6 and 13.3 g, respectively. Mean lengths of age I and II sockeye salmon smolt were 88.8 and 110.8 mm, respectively. Mean weight and length of age II coho salmon smolt were 24.4 g and 131.5 mm, respectively. Mean weights of age I and II sockeye salmon smolt were greater than the grand means for past years, but mean lengths were less than the grand means (1958-1982: age I smolt weight and length, 6.6 g and 91 mm, respectively; age II smolt weight and length, 12.4 g and 114 mm, respectively) (Table 19).

Weather and river conditions were recorded at the sonar site intermittently during 23 May through 11 June (Table 20). Mean air and water temperatures during this period were 11.6°C (range, 8.0-19.0°C) and 7.3°C (range, 6.0-8.5°C), respectively.

LITERATURE CITED

Bill, D.L. 1975. 1974 Naknek River sockeye salmon smolt studies. Pages 14-23 in P. Krasnowski, editor. 1974 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 20, Juneau, Alaska.

Bill, D.L. 1976. 1975 Naknek River sockeye salmon smolt studies. Pages 10-19 in P. Krasnowski, editor. 1975 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 25, Juneau, Alaska.

Bill, D.L. 1977. 1976 Naknek River sockeye salmon smolt studies. Pages 14-23 in N. Newcome, editor. 1976 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 33, Juneau, Alaska.

Biwer, D.A. 1972. 1970 Naknek River sockeye salmon smolt studies. Pages 24-31 in P.A. Russell, editor. 1970 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 4, Juneau, Alaska.

Bue, B.G. 1982. 1981 Egegik River sockeye salmon smolt studies. Pages 15-27 in D.M. Eggers and H.J. Yuen, editors. 1982 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 103, Juneau, Alaska.

Bue, B.G. 1984. 1982 Egegik River sockeye salmon smolt studies. Pages 28-40 in D.M. Eggers and H.J. Yuen, editors. 1982 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 103, Juneau, Alaska.

Cochran, W.G. 1963. Sampling Techniques. Second Edition. John Wiley and Sons, New York, N.Y. 413 p.

Eggers, D.M. 1984. 1982 Ugashik River sockeye salmon smolt studies. Pages 41-46 in D.M. Eggers and H.J. Yuen, editors. 1982 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 103, Juneau, Alaska.

Huttunen, D.C. 1980. 1978 Bristol Bay special sockeye salmon smolt studies. Pages 30-34 in C.P. Meacham, editor. 1978 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 44, Juneau, Alaska.

Huttunen, D.C. 1984. 1982 Naknek River sockeye salmon smolt studies. Pages 14-27 in D.M. Eggers and H.J. Yuen, editors. 1982 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 103, Juneau, Alaska.

Jaenicke, H.W. 1963. Ugashik River smolt studies a preliminary report of the 1962 season. Manuscript Report 63-5. United States Department of the Interior, Bureau of Commercial Fisheries, Auke Bay, AK.

McCurdy, M.L. 1972a. 1971 Naknek River sockeye salmon smolt studies. Pages 29-34 in P.A. Russell and M.L. McCurdy, editors. 1971 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report No. 2, Juneau, Alaska.

McCurdy, M.L. 1972b. 1969 Kvichak River sockeye salmon smolt studies. Pages 1-34 in M.L. McCurdy, editor. 1969 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 3, Juneau, Alaska.

McCurdy, M.L. 1974a. 1972 Naknek River sockeye salmon smolt studies. Pages 38-48 in K.P. Parker, editor. 1972 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 13, Juneau, Alaska.

McCurdy, M.L. 1974b. 1973 Naknek River sockeye salmon smolt studies. Pages 23-32 in K.P. Parker, editor. 1973 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report No. 14, Juneau, Alaska.

Nelson, M.L. 1965. Abundance, size, age and survival of red salmon smolts from the Ugashik Lakes system, Bristol Bay, 1964. Alaska Department of Fish and GAme, Division of Commercial Fisheries, Informational Leaflet 62, Juneau, Alaska.

Nelson, M.L. 1966. Abundance, size, age and survival of red salmon smolts from the Ugashik Lakes system, Bristol Bay, 1965. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 85, Juneau, Alaska.

Nelson, M.L. 1969. 1967 Ugashik River red salmon smolt studies. Pages 26-32 in D.M. Stewart, editor. 1967 Bristol Bay red salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 134, Juneau, Alaska.

Nelson, M.L., and H.W. Jaenicke. 1965. Abundance, size and age of red salmon smolts from the Ugashik Lakes system, Bristol Bay, 1963. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 49, Juneau, Alaska.

Paulus, R.D. 1972. 1969 Egegik River sockeye salmon smolt studies. Pages 62-65 in M.L. McCurdy, editor. 1969 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 3, Juneau, Alaska.

Paulus, R.D., and M.L. McCurdy. 1972. 1970 Kvichak River sockeye salmon smolt studies. Pages 1-13 in P.A. Russell, editor. 1970 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 4, Juneau, Alaska.

Paulus, R., and K. Parker. 1974. Kvichak River sockeye salmon smolt studies, 1955-1972. A historical review of sockeye salmon smolt research conducted on the Kvichak River, 1955-1972. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 166, Juneau, Alaska.

Randall, R.C. 1977. 1976 Kvichak River sockeye salmon smolt studies. Pages 1-13 in N. Newcome, editor. 1976 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 33, Juneau, Alaska.

Robertson, A.D. 1967. Naknek River red salmon smolt study, 1966. Pages 34-40 in D.M. Stewart, editor. 1966 Bristol Bay red salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 102, Juneau, Alaska.

Sanders, G.H. 1976. 1975 Ugashik River sockeye salmon smolt studies. Pages 20-28 in P. Krasnowski, editor. 1975 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 25, Juneau, Alaska.

Schroeder, T.R. 1972a. 1969 Ugashik River sockeye salmon smolt studies. Pages 35-45 in M.L. McCurdy, editor. 1969 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 3, Juneau, Alaska.

Schroeder, T.R. 1972b. 1970 Ugashik River sockeye salmon smolt studies. Pages 14-23 in P.A. Russell, editor. 1970 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 4, Juneau, Alaska.

Schroeder, T.R. 1974a. 1972 Ugashik River sockeye salmon smolt studies. Pages 49-56 in K.P. Parker, editor. 1972 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 13, Juneau, Alaska.

Schroeder, T.R. 1974b. 1973 Ugashik River sockeye salmon smolt studies. Pages 33-45 in K.P. Parker, editor. 1973 sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 14, Juneau, Alaska.

Schroeder, T.R. 1975. 1974 Ugashik River sockeye salmon smolt studies. Pages 24-37 in P. Krasnowski, editor. 1974 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 20, Juneau, Alaska.

Siedelman, D.L. 1969. Abundance, size and age of sockeye salmon smolt from the Ugashik Lakes system, 1968. Pages 46-61 in M.L. McCurdy, editor. 1968 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 138, Juneau, Alaska.

Siedelman, D.L. 1972. 1969 Naknek River sockeye salmon smolt studies. In M.L. McCurdy, editor. 1969 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 3, Juneau, Alaska.

Van Valin, G.R. 1969a. Naknek River red salmon smolt study, 1967. In D.M. Stewart, editor. 1967 Bristol Bay red salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 134, Juneau, Alaska.

Van Valin, G.R. 1969b. Naknek River sockeye salmon smolt study, 1968. In M.L. McCurdy, editor. 1968 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 138, Juneau, Alaska.

Yuen, H. 1978. 1977 Naknek River sockeye salmon smolt studies. Pages 12-23 in H. Yuen, editor. 1977 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 41, Juneau, Alaska.

Table 1. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Naknek River, Bristol Bay, Alaska, 1983. False counts were deleted, and interpolations were made for time missed when sonar not operated.

	Sonar Counts			
	Transducer Array			
Date a/	Inshore	Center	Offshore	Total
5 19	3,168	10,455	2,511	16,134
5 20	3,476	3,498	2,802	9,776
5 21	16,098	14,895	15,261	46,254
5 22	5,468	23,761	17,885	47,114
5 23	5,333	34,370	8,279	47,982
5 24	7,956	70,439	27,747	106,142
5 25	14,330	38,881	22,213	75,424
5 26	31,462	121,941	66,960	220,363
5 27	12,800	20,954	13,619	47,373
5 28	11,933	48,162	12,960	73,055
5 29	11,244	39,237	28,956	79,437
5 30	13,618	24,367	8,823	46,808
5 31	14,901	28,159	16,800	59,860
6 1	10,555	33,090	33,317	76,962
6 2	11,692	12,376	25,808	49,876
6 3	5,358	9,404	40,556	55,318
6 4	2,636	2,521	5,993	11,150
6 5	9,250	6,419	8,154	23,823
6 6	3,260	2,932	3,430	9,622
6 7	3,959	2,089	2,700	8,748
6 8	7,746	11,471	17,220	36,437
6 9	12,514	8,508	11,752	32,774
6 10	14,187	23,166	15,517	52,870
6 11	19,139	29,701	53,105	101,945
6 12	18,589	42,240	39,313	100,142
6 13	10,459	22,563	40,502	73,524
6 14	25,259	27,625	20,991	73,875
6 15	13,104	15,941	17,188	46,233
6 16	13,393	14,170	33,327	60,890
6 17	15,707	9,261	15,055	40,023
6 18	10,544	7,394	0	17,938
6 19	9,506	11,513	14,347	35,366
6 20	8,081	9,550	7,707	25,338
6 21	6,818	6,097	4,791	17,706
6 22	7,665	7,548	11,940	27,153
6 23	8,926	19,032	26,298	54,256

-Continued-

Table 1. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Naknek River, Bristol Bay, Alaska, 1983. False counts were deleted, and interpolations were made for time missed when sonar not operated (continued).

	Sonar Counts			
	Transducer Array			
Date a/	Inshore	Center	Offshore	Total
6 24	10,047	24,996	13,799	48,842
6 25	11,486	11,120	10,553	33,159
6 26	19,467	25,405	20,042	64,914
6 27	7,090	13,319	12,591	33,000
6 28	7,994	5,965	8,003	21,962
6 29	8,081	6,147	6,911	21,139
6 30	8,833	3,278	2,477	14,588
7 1	12,319	4,303	3,048	19,670
7 2	10,439	5,215	6,403	22,057
7 3	3,367	3,314	1,808	8,489
7 4	5,272	5,393	7,661	18,326
7 5	4,443	5,024	3,946	13,413
Total	508,972	927,209	791,069	2,227,250
Percent	22.85	41.63	35.52	100.00

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Naknek River, Bristol Bay, Alaska, 1983.

	Age I		Age II		Age III		All Ages	
Date a/	Number	Percent	Number	Percent	Number	Percent	Daily Total	Cumulative Total
5 19	3,524	0.78	446,857	98.90	1,430	0.32	451,812	451,812
5 20	1,932	0.78	245,038	98.90	784	0.32	247,755	699,568
5 21	8,983	0.78	1,139,050	98.90	3,647	0.32	1,151,680	1,851,249
5 22	5,356	0.78	679,223	98.90	2,174	0.32	686,755	2,538,004
5 23	10,639	0.78	1,348,973	98.90	4,319	0.32	1,363,931	3,901,936
5 24	13,171	0.78	1,670,028	98.90	5,347	0.32	1,688,546	5,590,483
5 25	9,121	0.78	1,156,548	98.90	3,703	0.32	1,169,372	6,759,855
5 26	2,958,431	50.31	2,921,973	49.69	0		5,880,405	12,640,261
5 27	536,967	50.31	530,350	49.69	0		1,067,318	13,707,579
5 28	800,553	50.31	790,688	49.69	0		1,591,242	15,298,821
5 29	668,606	37.31	1,123,424	62.69	0		1,792,031	17,090,852
5 30	372,011	37.31	625,071	62.69	0		997,082	18,087,935
5 31	401,192	37.31	674,103	62.69	0		1,075,296	19,163,231
6 1	1,211,019	74.63	411,678	25.37	0		1,622,697	20,785,928
6 2	809,949	74.63	275,337	25.37	0		1,085,286	21,871,215
6 3	895,148	74.63	304,300	25.37	0		1,199,448	23,070,664
6 4	118,718	58.57	83,959	41.42	0		202,677	23,273,341
6 5	317,625	58.57	224,628	41.42	0		542,254	23,815,596
6 6	156,788	70.98	64,102	29.02	0		220,891	24,036,487
6 7	158,070	79.72	40,224	20.28	0		198,294	24,234,782
6 8	693,637	79.72	176,509	20.28	0		870,147	25,104,929
6 9	600,362	79.25	157,192	20.75	0		757,555	25,862,485
6 10	1,308,652	95.58	60,445	4.41	0		1,369,097	27,231,583
6 11	2,325,078	95.58	107,393	4.41	0		2,432,472	29,664,055
6 12	2,426,861	95.58	112,094	4.41	0		2,538,956	32,203,012

-Continued-

Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Naknek River, Bristol Bay, Alaska, 1983 (continued).

Date a/	Age I		Age II		Age III		All Ages	
	Number	Percent	Number	Percent	Number	Percent	Daily Total	Cumulative Total
6 13	1,780,659	95.58	82,247	4.41	0		1,862,906	34,065,918
6 14	2,049,993	95.58	94,687	4.41	0		2,144,681	36,210,600
6 15	1,209,738	90.72	123,674	9.27	0		1,333,412	37,544,012
6 16	1,306,938	90.72	133,610	9.27	0		1,440,549	38,984,562
6 17	920,877	90.66	94,870	9.34	0		1,015,748	40,000,311
6 18	525,872	95.59	24,260	4.41	0		550,133	40,550,445
6 19	930,519	95.59	42,929	4.41	0		973,448	41,523,894
6 20	699,163	95.81	29,519	4.05	1,094	0.15	729,778	42,253,672
6 21	482,213	95.81	20,359	4.05	754	0.15	503,328	42,757,000
6 22	706,257	97.27	19,821	2.73	0		726,079	43,483,079
6 23	1,434,823	98.34	24,220	1.66	0		1,459,044	44,942,123
6 24	1,343,922	94.73	74,714	5.27	0		1,418,637	46,360,761
6 25	880,445	94.73	48,948	5.27	0		929,393	47,290,154
6 26	1,567,607	94.73	87,150	5.27	0		1,654,758	48,944,912
6 27	789,959	94.73	43,917	5.27	0		833,876	49,778,789
6 28	523,494	94.73	29,103	5.27	0		552,597	50,331,387
6 29	516,235	94.84	28,075	5.16	0		544,311	50,875,698
6 30	390,287	94.84	21,225	5.16	0		411,513	51,287,211
7 1	464,510	94.84	25,262	5.16	0		489,772	51,776,984
7 2	511,454	94.84	27,815	5.16	0		539,270	52,316,255
7 3	211,204	94.84	11,486	5.16	0		222,691	52,538,946
7 4	403,227	94.84	21,929	5.16	0		425,157	52,964,103
7 5	336,422	94.84	18,296	5.16	0		354,718	53,318,822
Total	36,798,239	69.02	16,497,326	30.94	23,256	0.04	53,318,822	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 3. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Naknek River, Bristol Bay, Alaska, 1983.

Date a/	Mean Weight of Smolt (g)	Smolt per Count
5 17	14.4	2.9
5 19	no sample	2.9
5 20	no sample	2.9
5 21	no sample	2.9
5 22	14.8	2.8
5 23	no sample	2.9
5 24	14.4	2.9
5 25	14.2	2.9
5 26	no sample	3.6
5 27	9.6	4.3
5 28	10.7	3.9
5 29	9.6	4.3
5 30	10.5	4.0
5 31	12.1	3.4
6 1	9.9	4.2
6 2	9.0	4.6
6 3	8.5	4.9
6 4	10.7	3.9
6 5	8.9	4.7
6 6	8.9	4.7
6 7	8.9	4.7
6 8	8.4	4.9
6 9	8.7	4.8
6 10	no sample	5.0
6 11	no sample	5.0
6 12	no sample	5.0
6 13	7.8	5.3
6 14	7.3	5.7
6 15	7.2	5.8
6 16	8.2	5.1
6 17	7.9	5.3
6 18	7.3	5.7
6 19	7.4	5.6
6 20	7.3	5.7
6 21	7.4	5.6
6 22	7.5	5.6
6 23	7.5	5.5
6 24	7.6	5.5
6 25	7.4	5.6
6 26	no sample	5.4
6 27	no sample	5.4
6 28	8.0	5.2

-Continued-

Table 3. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Naknek River, Bristol Bay, Alaska, 1983 (continued).

Date a/	Mean Weight of Smolt (g)	Smolt per Count
6 29	8.0	5.2
6 30	7.3	5.7
7 1	no sample	5.4
7 2	no sample	5.4
7 3	8.2	5.1
7 4	8.7	4.8
7 5	8.0	5.2

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Naknek River, Bristol Bay, Alaska, 1983. A dash (-) indicates missing data.

	Age I					Age II					Age III				
Date a/	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5 17	0	0.0	0.0	0.00	0	121	0.3	14.4	0.09	220	-		-		
5 22	102	0.0	9.8	0.00	1	118	0.5	14.8	0.15	224	-		-		0
5 24	99	0.0	8.0	0.10	2	118	0.6	14.5	0.20	102	135		19.7		1
5 25	0	0.0	0.0	0.00	0	116	0.5	14.2	0.15	102	-		-		0
5 27	95	0.7	8.2	0.16	60	108	0.7	11.6	0.20	41	-		-		0
5 28	96	0.5	8.4	0.11	136	110	0.4	12.3	0.13	194	-		-		0
5 29	95	1.4	8.2	0.33	13	106	1.5	10.6	0.40	17	-		-		0
5 30	98	0.3	8.8	0.07	149	109	0.4	12.1	0.12	159	-		-		0
5 31	99	0.6	9.1	0.14	37	112	0.6	12.9	0.17	146	-		-		0
6 1	98	0.4	8.8	0.11	109	108	0.6	11.8	0.20	68	-		-		0
6 2	95	0.5	8.2	0.13	165	109	1.1	12.4	0.34	40	-		-		0
6 3	94	0.4	7.8	0.11	153	108	1.3	11.6	0.37	34	-		-		0
6 4	92	0.6	7.4	0.15	86	114	0.7	13.6	0.25	94	-		-		0
6 5	92	0.4	7.5	0.09	197	110	0.6	12.2	0.17	87	-		-		0
6 6	93	0.2	7.6	0.06	472	109	0.7	12.1	0.20	193	-		-		0
6 7	95	0.4	8.0	0.10	130	109	0.8	11.9	0.24	41	-		-		0
6 8	94	0.3	7.8	0.06	352	109	0.8	11.8	0.22	70	-		-		0
6 9	94	0.2	7.7	0.06	317	111	0.9	12.6	0.26	83	-		-		0
6 13	93	0.3	7.5	0.06	188	111	1.8	12.5	0.64	13	-		-		0
6 14	92	0.2	7.2	0.04	456	106	2.3	11.1	0.64	11	-		-		0
6 15	90	0.2	7.1	0.05	335	107	1.7	11.9	0.84	5	-		-		0
6 16	92	0.3	7.4	0.06	403	109	0.7	12.0	0.19	83	-		-		0
6 17	91	0.2	7.3	0.05	495	112	1.1	13.1	0.37	51	-		-		0
6 18	91	0.2	7.1	0.05	378	109	1.9	12.2	0.60	16	-		-		0
6 19	91	0.2	7.2	0.05	320	111	1.8	12.6	0.57	16	-		-		0

-Continued-

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Naknek River, Bristol Bay, Alaska, 1983. A dash (-) indicates missing data (continued).

	Age I					Age II					Age III				
Date a/	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
6 20	91	0.2	7.1	0.05	317	109	2.7	11.9	0.79	12	122		16.6		1
6 21	91	0.3	7.2	0.06	236	110	1.8	12.3	0.59	11	-		-		0
6 22	92	0.2	7.4	0.04	392	106	1.5	10.8	0.46	11	-		-		0
6 23	93	0.2	7.5	0.04	474	106	1.0	10.8	0.28	8	-		-		0
6 24	91	0.3	7.2	0.08	180	111	2.0	12.6	0.70	13	-		-		0
6 25	92	0.6	7.4	0.16	51	103	0.0	10.3	0.00	1	-		-		0
6 28	94	0.3	7.8	0.08	195	106	1.7	11.4	0.48	15	-		-		0
6 29	94	0.5	7.8	0.10	71	100	1.2	9.6	0.48	9	-		-		0
6 30	92	0.6	7.3	0.12	26	-		-		0	-		-		0
7 3	95	0.4	8.1	0.09	135	106	1.8	11.0	0.65	5	-		-		0
7 4	97	0.3	8.5	0.09	87	105	0.5	10.8	0.12	8	-		-		0
7 5	94	0.3	7.9	0.08	153	106	1.2	11.1	0.29	4	-		-		0
	--		---		-----	---		----		-----	---		----		---
Totals					7,271					2,207					2
Means	94		8.0			110		12.2			133		19.1		

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 5. Mean fork length (mm) and weight (g) of sockeye salmon smolt sampled from the Naknek River, Bristol Bay, Alaska, 1957-1983. A dash (-) indicates data not available.

			Age I		Age II		Age III		
Year of Migration	Sample Dates	Sample Size	Mean Length	Mean Weight	Mean Length	Mean Weight	Mean Length	Mean Weight	Reference
1957	-	-	111	13.1	112	13.1	-	-	USF&WS (unpublished)
1958	-	-	91	6.9	114	11.3	-	-	"
1959	-	-	97	8.2	106	10.1	-	-	"
1960	-	-	99	8.8	109	11.9	-	-	"
1961	-	-	103	10.8	113	13.8	-	-	"
1962	-	-	105	10.4	112	12.5	-	-	"
1963	-	-	98	8.1	114	12.8	-	-	"
1964	-	-	97	7.7	110	11.0	-	-	"
1965	-	-	99	8.4	114	13.0	-	-	"
1966	31 May-13 July	933	106	10.6	118	14.2	-	-	"
1967	27 May- 9 July	855	113	13.1	119	14.7	-	-	Van Valin (1969a)
1968	23 May-12 August	1,380	99	8.4	108	11.1	-	-	Van Valin (1969b)
1969	30 May-27 June	1,079	100	7.5	112	12.1	-	-	Siedelman (1972)
1970	29 May- 5 July	932	100	9.0	114	12.1	-	-	Biwer (1972)
1971	6 June-7 July	-	102	8.8	120	13.5	-	-	McCurdy (1972a)
1972	8 June-6 July	689	98	9.1	110	11.9	-	-	McCurdy (1974a)
1973	28 May-26 June	745	106	10.7	114	12.9	122	15.2	McCurdy (1974b)
1974	22 May-27 June	827	104	10.3	118	14.5	109	11.3	Bill (1975)
1975	28 May- 9 July	1,037	98	8.3	111	12.1	109	11.5	Bill (1976)
1976	22 May-26 June	833	91	7.2	107	13.4	131	2.2	Bill (1977)
1977	20 May-23 June	1,178	92	7.2	113	11.9	-	-	Yuen (1978)
1978	1 June	239	96	8.3	105	11.0	-	-	Huttenun (1980)
1982	24 May-10 July	3,222	94	8.0	100	14.7	-	-	Huttenun (1984)
			---	----	---	----	---	----	
		Mean	100	8.3	112	12.6	118	15.1	
1983	17 May- 5 July	2,480	94	8.0	110	12.2	133	19.1	

Table 6. Climatological and hydrological observations made at sockeye salmon smolt counting site, Naknek River, Bristol Bay, Alaska, 1983. A dash (-) indicates data not available.

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp. (C)	Water Temp. (C)	Precipitation (mm)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr				
5 20	2	2	calm	42 SSW	-	9.5-10.0	0.00	murky
5 21	4	4	3 SSE	3 SSW	4.0-17.0	8.0- 9.0	5.75	murky
5 22	4	3	3 SSW	calm	6.0-15.5	9.0-10.0	1.00	murky
5 23	2	4	25 SSW	calm	7.0-15.7	10.0	0.75	murky
5 24	1	3	calm	calm	8.0-15.5	9.0-11.5	0.25	murky
5 25	5	3	calm	calm	6.0-13.0	8.0-12.0	0.25	murky
5 26	3	3	17 SW	13-20 E	6.0-15.5	8.0-12.5	0.25	murky
5 27	1	2	25 SW	calm	7.0-18.0	-	0.00	murky
5 28	1	2	8 SW	calm	9.0-20.5	13.5	0.00	murky
5 29	2	4	calm	17 SE	9.0-17.5	10.0-12.5	1.25	murky
5 30	2	4	42 S	calm	4.0-18.5	11.0-12.0	0.00	murky
5 31	4	3	calm	10-17 SE	3.0-13.5	11.0-12.0	6.50	murky
6 1	4	2	calm	calm	5.0-15.5	10.0-11.50	1.00	murky
6 2	3	4	calm	calm	2.0-12.0	10.0-12.0	2.50	murky
6 3	4	4	calm	calm	2.0-10.5	11.0	2.75	murky
6 4	2	4	8 S	calm	6.0-12.5	10.0-12.5	0.00	murky
6 5	4	1	calm	calm	1.0-19.5	11.0-14.0	0.00	murky
6 6	5	1	calm	calm	1.0-20.5	11.0	0.00	clear
6 7	1	1	8 W	calm	0.0-21.5	12.0-15.0	0.00	clear
6 8	1	1	calm	12-15 N	0.0-20.5	13.0-15.0	0.00	clear
6 9	1	1	25-42 N	8 N	5.0-18.5	12.5-14.0	0.00	clear
6 10	1	1	8-17 N	calm	10.0-18.0	12.5-14.5	0.00	clear
6 11	3	4	calm	25 SE	10.0-11.0	13.0-14.0	0.00	clear
6 12	2	3	8-17 SW	calm	7.5-13.0	12.5-14.0	1.50	clear
6 13	3	4	calm	calm	6.0-14.0	13.5-14.5	0.00	murky

-Continued-

Table 6. Climatological and hydrological observations made at sockeye salmon smolt counting site, Naknek River, Bristol Bay, Alaska, 1983. A dash (-) indicates data not available (continued).

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp. (C)	Water Temp. (C)	Precipitation (mm)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr				
6 14	3	-	calm	calm	7.0-15.0	12.0-15.0	0.25	murky
6 15	3	1	10 NE	calm	8.0-15.0	14.0-16.0	2.75	murky
6 16	4	2	8 SE	calm	2.0-19.0	14.0-15.0	2.00	murky
6 17	4	3	13 SE	calm	7.0-18.0	14.0	0.00	murky
6 18	1	3	7 NE	10-15 S	1.0-17.0	14.0-15.0	0.25	clear
6 19	4	4	calm	calm	2.0-17.0	14.0	0.75	murky
6 20	3	3	13-17 SE	calm	7.0-16.0	14.0-14.5	0.00	murky
6 21	4	4	calm	calm	9.0-14.0	14.0-14.5	0.00	murky
6 22	3	2	- NE	10 SE	6.0-18.0	14.0-15.0	0.00	clear
6 23	4	4	10-17 NE	10-20 E	4.0-10.0	14.0-14.5	0.25	murky
6 24	3	4	8-15 NE	calm	8.0-16.0	13.5-14.0	1.00	murky
6 25	3	4	calm	8 SE	7.0-19.0	13.5-14.0	7.50	murky
6 26	2	3	17-42 SE	17-30 E	4.0-12.0	13.5-14.0	0.00	murky
6 27	4	3	8-33 N	calm	11.0-17.0	13.0-13.5	0.00	murky
6 28	4	3	calm	10-15 NE	6.0-19.0	13.5-14.5	0.00	murky
6 29	1	3	8 NE	10-17 NE	4.0-16.0	14.0	0.00	murky
6 30	2	3	calm	calm	2.0-20.0	13.5-14.5	0.25	murky
7 1	3	3	calm	8-13 S	7.0-20.0	14.0-14.5	1.00	murky
7 2	-	3	- -	7-10 SE	7.0-17.0	14.0	0.50	murky
7 3	3	2	10-15 SW	7-10 SW	8.0-18.0	13.5-14.0	-	murky
7 4	5	3	8-15 SW	calm	3.0-20.0	14.0-15.0	-	murky
7 5	3	3	calm	10-17 SW	10.0-23.0	14.5	0.50	clear
7 6	4	-	17-33 SW	- -	-	-	-	clear

a/ 1 = cloud cover not more than 1/10
2 = cloud cover not more than 1/2
3 = cloud cover more than 1/2
4 = completely overcast
5 = fog

Table 7. Water temperatures at sockeye salmon smolt counting site, Naknek River, Bristol Bay, Alaska, 1967-1983.

Year	Sample Period	Water Temperature (C) Minimum	Maximum	Mean	
1967	27 May-11 July	10.6	15.0	13.0	Van Valin (1969a)
1968	21 May-14 July	7.2	16.7	12.9	Van Valin (1969b)
1969	27 May-16 July	6.7	13.9	11.0	Siedelman (1972)
1970	27 May-16 June	11.1	14.4	12.1	Biwer (1972)
1971	7 June- 7 July	4.4	10.0	7.2	McCurdy (1972a)
1972	8 June- 6 July	6.7	14.4	10.1	McCurdy (1974a)
1973	29 May-26 June	6.9	15.9	11.1	McCurdy (1974b)
1974	21 May-27 June	8.1	14.3	12.1	Bill (1975)
1975	28 May- 9 July	3.5	13.2	9.0	Bill (1976)
1976	22 May-26 June	4.6	12.8	9.5	Bill (1977)
1982	21 May-10 July	5.0	14.4	8.9	Huttenun (1984)
	Mean	6.8	14.1	10.6	
1983	20 May- 6 July	8.0	16.0	12.8	

Table 8. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Egegik River, Bristol Bay, Alaska, 1983. False counts were deleted, and interpolations were made for time missed when sonar not operated.

	Sonar Counts			
	Transducer Array			
Date a/	Inshore	Center	Offshore	Total
5 17	6,452	12,636	8,240	27,328
5 18	639	9,304	2,369	12,312
5 19	248	13,373	3,751	17,372
5 20	540	24,757	1,041	26,338
5 21	14,071	138,864	89,262	242,197
5 22	193	52,543	2,369	55,105
5 23	1,763	129,842	27,503	159,108
5 24	1,592	81,799	20,608	103,999
5 25	1,421	33,756	13,713	48,890
5 26	2,464	154,882	11,096	168,442
5 27	5,544	13,072	2,315	20,931
5 28	174	11,721	1,546	13,441
5 29	109,612	257,164	34,666	401,442
5 30	5,446	44,383	16,769	66,598
5 31	12,102	84,323	2,832	99,257
6 1	9,401	15,002	1,872	26,275
6 2	144	715	1,331	2,190
6 3	918	2,487	1,595	5,000
6 4	1,954	11,966	7,467	21,387
6 5	3,474	4,389	809	8,672
6 6	3,387	3,888	504	7,779
6 7	1,450	4,523	435	6,408
6 8	557	5,805	1,612	7,974
6 9	4,408	3,874	565	8,847
6 10	290	128	137	555
Total	188,244	1,115,196	254,407	1,557,847
Percent	12.08	71.59	16.33	100.00

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 9. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Egegik River, Bristol Bay, Alaska, 1983.

	Age I		Age II		All Ages	
Date a/	Number	Percent	Number	Percent	Daily Total	Cumulative Total
5 17	9,894	3.06	313,244	96.94	323,139	323,139
5 18	3,391	3.06	107,354	96.94	110,745	433,884
5 19	5,354	3.06	169,506	96.94	174,860	608,745
5 20	6,977	3.06	220,911	96.94	227,889	836,634
5 21	78,042	3.06	2,470,709	96.94	2,548,752	3,385,386
5 22	51,729	9.45	495,672	90.55	547,402	3,932,789
5 23	169,933	9.45	1,628,309	90.55	1,798,243	5,731,032
5 24	59,905	5.48	1,032,439	94.52	1,092,345	6,823,377
5 25	28,904	5.48	498,159	94.52	527,064	7,350,441
5 26	98,811	5.48	1,702,963	94.52	1,801,774	9,152,216
5 27	24,217	5.48	417,382	94.52	441,599	9,593,816
5 28	7,310	5.48	125,994	94.52	133,305	9,727,121
5 29	294,902	5.48	5,082,491	94.52	5,377,393	15,104,515
5 30	319,485	37.03	543,172	62.97	862,657	15,967,173
5 31	482,950	37.03	821,087	62.97	1,304,038	17,271,211
6 1	179,361	42.61	241,604	57.39	420,965	17,692,176
6 2	11,782	42.61	15,870	57.39	27,653	17,719,829
6 3	30,944	42.61	41,683	57.39	72,628	17,792,458
6 4	118,900	42.61	160,161	57.39	279,062	18,071,520
6 5	59,899	42.61	80,685	57.39	140,584	18,212,105
6 6	62,126	42.61	83,686	57.39	145,813	18,357,918
6 7	56,149	42.61	75,634	57.39	131,783	18,489,702
6 8	48,837	42.61	65,784	57.39	114,622	18,604,324
6 9	29,762	20.00	119,051	80.00	148,814	18,753,138
6 10	2,750	20.00	11,000	80.00	13,750	18,766,889
Total	2,242,326	11.95	16,524,563	88.05	18,766,889	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 10. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Egegik River, Bristol Bay, Alaska, 1983.

Date a/	Mean Weight of Smolt (g)	Smolt per Count
5 17	14.4	2.9
5 18	14.6	2.8
5 19	12.4	3.4
5 20	15.6	2.7
5 21	14.1	3.0
5 22	14.5	2.9
5 23	12.7	3.3
5 24	13.7	3.0
5 25	13.5	3.1
5 26	13.5	3.1
5 27	no sample	3.0
5 28	14.6	2.9
5 29	13.2	3.2
5 30	11.7	3.5
5 31	12.0	3.5
6 1	11.7	3.6
6 2	11.7	3.6
6 3	11.3	3.7
6 4	11.7	3.6
6 5	11.8	3.5
6 6	10.5	4.0
6 7	no sample	4.0
6 8	10.5	4.0
6 9	12.1	3.4
6 10	no sample	3.4

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 11. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Egegik River, Bristol Bay, Alaska, 1983.

	Age I					Age II				
Date a/	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (gm)	Std Error	Sample Size
5 17	0	0.0	0.0	0.00	0	121	0.3	14.4	0.09	220
5 18	0	0.0	0.0	0.00	0	120	0.5	14.6	0.13	98
5 19	95	0.0	6.9	0.00	1	118	1.6	13.1	0.55	8
5 20	0	0.0	0.0	0.00	0	122	0.7	15.6	0.27	55
5 21	102	1.2	9.7	0.31	12	117	0.3	14.3	0.09	274
5 22	103	0.9	9.9	0.24	6	120	0.3	14.6	0.08	279
5 23	98	0.8	8.8	0.18	44	116	0.3	13.5	0.09	218
5 24	101	2.0	9.9	0.79	6	118	0.4	13.8	0.12	178
5 25	102	1.3	9.1	0.40	6	119	0.7	13.9	0.25	58
5 26	101	0.6	9.4	0.25	3	117	0.8	13.8	0.30	50
5 28	0	0.0	0.0	0.00	0	121	0.8	14.5	0.36	37
5 29	103	0.5	9.8	0.14	23	116	0.4	13.5	0.10	229
5 30	101	0.4	9.3	0.08	115	115	0.4	13.3	0.13	179
5 31	101	0.4	9.5	0.11	151	115	0.4	13.4	0.13	281
6 1	98	1.0	8.5	0.22	35	116	0.9	13.4	0.32	64
6 2	101	0.8	9.8	0.27	17	112	1.2	12.7	0.45	31
6 3	103	0.8	10.2	0.23	45	109	1.1	12.2	0.38	53
6 4	102	0.8	9.5	0.29	33	114	1.0	13.0	0.34	53
6 5	103	1.3	9.7	0.35	20	115	1.5	13.2	0.46	31
6 6	103	2.1	10.3	0.90	3	106	1.9	10.6	0.61	4
6 8	102	1.5	9.4	0.34	11	112	2.0	12.2	0.61	7
6 9	117	0.0	10.9	0.00	1	114	3.5	12.4	0.42	4
Totals					532					2,099
Means	102		9.5			117		13.7		

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 12. Mean fork length (mm) and weight (g) of sockeye salmon smolt sampled from the Egegik River, Bristol Bay, Alaska, 1939-1983. A dash (-) indicates data not available.

Year of Migration	Sample Dates	Sample Size	Age I Mean Length	Age I Mean Weight	Age II Mean Length	Age II Mean Weight	Age III Mean Length	Age III Mean Weight	
1939	-	-	96	-	105	-	-	-	USF&WS (unpublished)
1956	-	386	101	-	116	-	123	-	"
1957	-	236	107	-	120	-	130	-	"
1959	-	281	99	-	116	-	123	-	"
1960	-	159	106	-	115	-	140	-	"
1969	-	67	99	-	119	-	115	-	Paulus (1972)
1977	27-29 May	299	110	11.3	116	13.3	-	-	ADF&G (unpublished)
1978	19-22 May	319	104	10.1	122	15.4	130	18.1	Huttenun (1980)
1981	15 May- 6 June	549	105	9.1	122	16.6	128	19.1	Bue (1982)
1982	27 May-15 June	881	104	9.2	130	17.1	145	23.5	Bue (1984)
		Mean	103	9.9	118	15.6	129	20.2	
1983	17 May- 9 June	2,631	101	9.3	116	13.6	-	-	

Table 13. Climatological and hydrological observations made at sockeye salmon smolt counting site, Egegik River, Bristol Bay, Alaska, 1983. A dash (-) indicates missing data.

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp. (C)	Mean Water Temp. (C)	Precipitation	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr				
5 18	3	-	8 E	- -	-	-	trace	clear
5 19	1	1	- -	8-17 WNW	-	7.0	0	clear
5 20	-	2	- -	42 ENE	-	7.5	0	clear
5 21	-	3	- -	calm	3.5	7.0	0	clear
5 22	-	-	- -	- -	-	11.0	0	clear
5 23	-	3	- -	8 ENE	-	7.0	0	clear
5 24	3	1	- -	8-17 W	-	8.2	0	clear
5 25	-	-	- -	- -	-	8.5	0	clear
5 26	3	2	- -	8-17 ENE	-	9.5	0	clear
5 27	1	2	- -	17 WNW	-	8.8	trace	clear
5 28	1	3	- -	- ENE	-	8.0	0	clear
5 29	3	2	- -	- ENE	-	8.0	trace	clear
5 30	-	-	- -	- -	-	11.0	0	clear
5 31	4	-	0-8 ENE	- -	-	9.8	0	clear
6 1	3	-	8-17 E	0-8 ENE	7.0	10.0	trace	clear
6 2	1	4	- SE	0-8 W	9.0	11.5	trace	clear
6 3	4	4	0-8 E	0-8 ESE	6.0	12.5	0	clear
6 4	3	-	0-3 ENE	- -	10.0	9.5	0	clear
6 5	4	-	calm	0-8 W	9.0	9.1	0	clear
6 6	-	1	calm	0-8 NW	14.5	11.0	0	clear
6 7	-	1	- -	0-8 E	9.0	10.2	0	clear
6 8	1	-	0-8 E	- -	-	10.0	0	clear
6 9	1	1	17-50 WNW	8-17 W	27.0	9.0	0	clear
6 10	1	1	- -	- -	-	11.0	0	clear

a/ 1 = cloud cover not more than 1/10
2 = cloud cover not more than 1/2
3 = cloud cover more than 1/2
4 = completely overcast
5 = fog

Table 14. Sonar counts recorded from two 10 transducer arrays at the sockeye salmon smolt counting site on the Ugashik River, Bristol Bay, Alaska, 1983. False counts were deleted, and interpolations were made for time missed when sonar not operated.

	Sonar Counts		
	Transducer Array		
Date a/	Inshore	Center	Total
5 21	21,552	7,086	28,638
5 22	27,319	8,982	36,301
5 23	95,404	31,368	126,772
5 24	143,165	77,380	220,545
5 25	86,293	25,382	111,675
5 26	491,252	146,919	638,171
5 27	560,971	128,120	689,091
5 28	271,563	78,675	350,238
5 29	229,214	33,720	262,934
5 30	86,882	20,196	107,078
5 31	325,588	21,625	347,213
6 1	86,716	36,513	123,229
6 2	102,387	32,415	134,802
6 3	192,612	11,353	203,965
6 4	102,581	18,053	120,634
6 5	45,395	6,751	52,146
6 6	65,831	20,963	86,794
6 7	536,162	126,082	662,244
6 8	80,247	13,503	93,750
6 9	204,867	22,895	227,762
6 10	287,341	28,568	315,909
6 11	29,129	5,258	34,387
6 12	27,065	33,008	60,073
6 13	188,193	36,236	224,429
6 14	105,753	10,227	115,980
6 15	50,193	5,663	55,856
6 16	57,203	12,569	69,772
Total	4,500,878	999,510	5,500,388
Percent	81.83	18.17	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 15. Daily number of sockeye and coho salmon smolt migrating seaward, estimated with a sonar unit, Ugashik River, Bristol Bay, Alaska, 1983.

	Sockeye Salmon						Coho Salmon	
	Age I		Age II		All Ages		Age II	
Date a/	Number	Percent	Number	Percent	Daily Total	Cumulative Total	Number	Percent
5 21	84,304	47.63	92,693	52.37	176,998	176,998	0	0.00
5 22	218,151	47.63	239,861	52.37	458,012	635,010	0	0.00
5 23	414,945	47.63	456,239	52.37	871,184	1,506,194	0	0.00
5 24	168,822	13.81	1,053,644	86.19	1,222,466	2,728,661	0	0.00
5 25	98,886	13.81	617,162	86.19	716,049	3,444,710	0	0.00
5 26	95,349	2.56	3,629,246	97.44	3,724,596	7,169,306	0	0.00
5 27	1,565,016	31.72	3,368,830	68.28	4,933,846	12,103,153	0	0.00
5 28	2,102,865	68.66	959,857	31.34	3,062,722	15,165,875	0	0.00
5 29	1,309,128	63.63	636,200	30.92	1,945,328	17,111,204	112,240	5.45
5 30	576,457	63.63	280,142	30.92	856,600	17,967,805	49,423	5.45
5 31	2,901,287	87.57	191,331	5.77	3,092,619	21,060,425	220,487	6.65
6 1	1,067,625	87.57	70,406	5.77	1,138,032	22,198,457	81,135	6.65
6 2	757,661	74.97	103,544	10.24	861,206	23,059,664	149,480	14.79
6 3	1,461,353	74.97	199,714	10.24	1,661,067	24,720,731	288,313	14.79
6 4	831,942	88.14	37,566	3.98	869,509	25,590,240	74,378	7.88
6 5	497,972	88.14	22,486	3.98	520,458	26,110,698	44,520	7.88
6 6	517,789	83.32	18,798	3.03	536,588	26,647,287	84,858	13.65
6 7	5,167,789	83.32	187,620	3.03	5,355,409	32,002,697	846,929	13.65
6 8	870,827	92.59	68,516	7.28	939,344	32,942,041	1,175	0.12
6 9	2,286,403	92.59	179,894	7.28	2,466,297	35,408,339	3,086	0.12
6 10	2,548,155	85.66	264,453	8.89	2,812,608	38,220,948	162,122	5.45
6 11	320,535	93.35	3,038	0.88	323,574	38,544,522	19,813	5.77
6 12	484,886	93.35	4,597	0.88	489,483	39,034,005	29,972	5.77

-Continued-

Table 15. Daily number of sockeye and coho salmon smolt migrating seaward, estimated with a sonar unit, Ugashik River, Bristol Bay, Alaska, 1983 (continued).

	Sockeye Salmon						Coho Salmon	
	Age I		Age II		All Ages		Age II	
Date a/	Number	Percent	Number	Percent	Daily Total	Cumulative Total	Number	Percent
6 13	2,498,130	97.90	17,606	0.69	2,515,736	41,549,742	35,979	1.41
6 14	1,280,809	93.92	9,819	0.72	1,290,628	42,840,371	73,167	5.37
6 15	583,705	93.92	4,474	0.72	588,180	43,428,552	33,344	5.37
6 16	586,630	90.38	18,628	2.87	605,259	44,033,811	43,812	6.75
Total	31,297,432	71.08	12,736,379	28.92	44,033,811		2,354,233	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 16. Adjustment factors used to expand sonar counts into estimated numbers of sockeye and coho salmon smolt, Ugashik River, Bristol Bay, Alaska, 1983.

Date a/	Mean Weight of Smolt (g)	Smolt per Count
5 21	12.9	3.2
5 22	6.3	6.6
5 23	11.6	3.6
5 24	13.6	3.1
5 25	12.6	3.3
5 26	13.8	3.0
5 27	11.5	3.6
5 28	9.2	4.5
5 29	10.8	3.8
5 30	9.7	4.3
5 31	9.2	4.5
6 1	7.8	5.3
6 2	10.7	3.9
6 3	9.2	4.5
6 4	10.7	3.9
6 5	7.8	5.3
6 6	11.2	3.7
6 7	8.8	4.7
6 8	8.4	5.0
6 9	7.9	5.2
6 10	9.2	4.5
6 11	8.4	5.0
6 12	7.7	5.4
6 13	7.3	5.7
6 14	7.4	5.6
6 15	7.7	5.4
6 16	8.9	4.7

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 17. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Ugashik River, Bristol Bay, Alaska, 1983.

	Age I					Age II				
Date a/	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (gm)	Std Error	Sample Size
5 21	87	1.5	7.3	0.34	16	112	0.4	13.7	0.14	108
5 22	83	0.8	6.2	0.10	124	98	3.4	9.7	0.88	3
5 23	88	0.7	7.5	0.20	77	112	0.4	13.6	0.12	161
5 24	91	1.2	8.5	0.27	31	114	0.4	14.2	0.11	242
5 25	93	0.4	8.7	0.11	112	111	0.2	13.3	0.06	577
5 26	95	1.1	9.4	0.29	11	113	0.3	13.9	0.07	418
5 27	90	0.5	7.6	0.14	138	111	0.3	13.3	0.09	297
5 28	89	0.3	7.5	0.08	368	110	0.5	12.9	0.12	168
5 29	91	0.3	8.3	0.10	184	111	0.4	13.2	0.12	180
5 30	88	0.5	7.3	0.12	187	107	0.9	12.1	0.26	31
5 31	85	0.4	6.5	0.09	132	107	3.3	12.4	0.87	5
6 1	88	0.3	7.4	0.07	415	108	0.9	12.5	0.24	38
6 2	89	0.4	7.7	0.09	258	107	0.8	12.2	0.21	69
6 3	82	0.6	5.7	0.14	83	104	6.5	11.4	2.05	2
6 4	90	0.4	7.8	0.09	133	110	3.2	13.1	0.85	6
6 5	89	0.2	7.6	0.05	531	110	2.2	13.1	0.60	24
6 6	90	0.3	7.8	0.07	159	112	3.0	13.6	0.81	8
6 7	86	0.2	6.9	0.03	919	112	2.2	13.8	0.58	22
6 8	89	0.3	7.7	0.07	207	114	2.3	14.7	0.69	22
6 9	89	0.2	7.6	0.05	382	109	1.4	12.8	0.36	20
6 10	89	0.2	7.7	0.04	549	113	1.0	13.9	0.29	57
6 11	88	0.2	7.2	0.06	294	118	0.0	14.8	0.05	2
6 12	85	0.3	6.6	0.07	164	108	3.0	11.7	0.05	2
6 13	87	0.2	7.0	0.05	426	113	6.8	14.0	1.80	3

-Continued-

Table 17. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Ugashik River, Bristol Bay, Alaska, 1983 (continued).

	Age I					Age II				
Date a/	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (gm)	Std Error	Sample Size
6 14	83	0.3	6.2	0.06	347	118	2.0	15.3	0.55	2
6 15	86	0.2	6.8	0.05	523	104	1.4	11.5	0.35	5
6 16	89	0.2	7.5	0.06	252	111	2.5	13.5	0.67	8
Totals					7,022					2,480
Means	89		7.6			111		13.3		

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 18. Mean fork length (mm) and weight (g) of coho salmon smolt captured in fyke nets, Ugashik River, Bristol Bay, Alaska, 1983.

	Age I					Age II					Age III				
Date a/	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5 31	126		19.2		1	133	2.90	25.7	1.82	18	130	1.50	22.4	0.40	2
6 2	127		20.4		1	128	1.60	22.0	0.79	37	159	5.70	40.7	3.96	7
6 3					0	136	4.40	26.4	2.59	15	145	6.10	30.1	4.48	3
6 4	98	13.00	11.0	3.50	2	135	3.00	24.6	1.87	21	151	10.20	35.6	5.74	3
6 7					0	130	2.40	23.8	1.49	18	146	5.50	33.4	3.73	5
6 11	116		17.8		1	122	2.20	20.3	1.37	17	143	5.30	30.7	2.79	4
Totals					5					126					24
Means	120		17.8			132		24.4			144		31.2		

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 19. Mean fork length (mm) and weight (g) of sockeye salmon smolt sampled from the Ugashik River Bristol Bay, Alaska, 1958-1983. A dash (-) indicates data not available.

Year of Migration	Sample Dates	Sample Size	Age I Mean Length	Age I Mean Weight	Age II Mean Length	Age II Mean Weight	Age III Mean Length	Age III Mean Weight	
1958	-	-	93	6.4	112	11.7	-	-	USF&WS (unpublished)
1959	-	-	90	6.1	120	13.5	-	-	"
1960	-	-	90	6.6	104	11.0	-	-	"
1961	-	-	90	6.7	112	12.2	-	-	"
1962	12 May-28 June	1,070	88	6.1	112	12.3	-	-	Jaenicke (1963)
1963	5 May-26 June	921	90	6.1	104	9.6	-	-	Nelson and Jaenicke (1965)
1964	15 May-20 June	4,042	92	6.9	118	12.7	-	-	Nelson (1965)
1965	13 May-20 June	3,296	94	6.9	114	12.5	-	-	Nelson (1966)
1967	15 May-12 June	966	88	6.0	113	12.2	-	-	Nelson (1969)
1968	13 May-24 June	6,727	93	6.5	113	10.7	-	-	Siedelman (1969)
1969	23 May- 6 June	567	97	7.5	121	14.5	-	-	Schroeder (1972a)
1970	15 May-10 June	907	97	7.7	125	15.9	-	-	Schroeder (1972b)
1972	28 May-20 June	615	81	5.0	112	11.2	129	14.3	Schroeder (1974a)
1973	17 May-12 June	1,189	93	7.2	113	11.9	132	20.1	Schroeder (1974b)
1974	17 May-17 June	355	94	7.4	119	13.6	-	-	Schroeder (1975)
1975	3-13 June	-	96	7.2	116	13.0	125	16.7	Sanders (1976)
1982	6- 8 June	512	88	6.3	113	13.0	138	22.5	Eggers (1984)
		Mean	91	6.6	114	12.4	131	18.4	
1983	21 May-16 June	9,502	89	7.6	111	13.2	-	-	

Table 20. Climatological and hydrological observations made at sockeye salmon smolt counting site, Ugashik River, Bristol Bay, Alaska, 1983. A dash (-) indicates missing data.

Date	Cloud Cover a/		Wind Velocity (km/hr)		Air Temp. (C)	Water Temp. (C)	Precipitation	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr				
5 23	3	2	calm	8 SW	-	-	0	clear
5 24	4	1	calm	25 SW	-	-	0	clear
5 25	1	2	33 W	25 SE	-	-	0	clear
5 26	-	-	- -	- -	-	-	-	-
5 27	-	-	- -	- -	-	-	-	-
5 28	1	3	calm	33+ SE	10.0	7.0	0	clear
5 29	4	3	- SE	33+ SE	8.5	7.0	trace	clear
5 30	-	-	-	- -	-	-	-	-
5 31	-	-	-	- -	-	-	-	-
6 1	-	-	-	- -	-	-	-	-
6 2	-	-	-	- -	-	-	-	-
6 3	-	-	-	- -	-	-	-	-
6 4	-	-	-	- -	-	-	-	-
6 5	-	3	-	5-17 W	6.0-22.0	7.5	0	clear
6 6	1	1	2-3 W	5-8 W	4.0-19.0	7.0-7.5	0	clear
6 7	4	1	3-7 SW	25 SE	5.0-23.0	6.0-7.5	0	clear
6 8	1	1	5-8 SE	17-25 NW	6.0-23.0	7.0-8.5	0	clear
6 9	1	1	5-8 W	17 W	6.0-16.0	8.0	0	clear
6 10	4	1	2-5 SE	2-5 W	4.0-23.0	6.5-7.0	0	clear
6 11	3	4	33-42 SE	33 SE	3.0-11.0	7.5-8.0	0	clear

a/ 1 = cloud cover not more than 1/10
2 = cloud cover not more than 1/2
3 = cloud cover more than 1/2
4 = completely overcast
5 = fog

WOOD RIVER SOCKEYE SALMON SMOLT STUDIES FOR 1983

By

Wesley Bucher
Alaska Department of Fish and Game
Division of Commercial Fisheries
Dillingham, Alaska

INTRODUCTION

Annual numbers of sockeye salmon smolt migrating to sea from the Wood River system have ranged from about 30 million to 100 million smolt since the sonar program began in 1975 (Krasnowski 1976). Most smolt migration has occurred during the 90-day period between 1 June and 30 August. Estimates of smolt numbers are required for forecasting adult returns and determining optimum spawning escapement levels.

Specific objectives of the Wood River smolt project have been: 1) to estimate numbers of seaward migrating sockeye salmon smolt, 2) to describe smolt migration patterns, 3) to determine the age, length, and weight composition of the smolt population, 4) to record the incidence of the cestode parasite *Triaenophorus crassus*, and 5) to record climatological and hydrological parameters which might affect migratory behavior.

MATERIALS AND METHODS

Sonar equipment used has been described by Krasnowski (1976 and 1977). The system consisted of four ladder-like arrays, each containing 10 upward facing transducers, which were anchored on the river bottom. The 10 transducer cables from each array were taped together and secured to the river bank with a safety line. All transducer cables were connected to the same electronic counting unit, which was powered by a 12 volt battery. The counting unit was kept in a canvas wall tent and continuously monitored by the field crew.

Installation and operation of the sonar gear has been described by Bucher (1980 and 1981). The same counting site has been used since 1975 (Krasnowski 1976). Actual placement of Arrays I, II, III, and IV in 1983 were 25.6, 37.5, 50.6, and 64.6 m from the north bank of the river, respectively.

Sonar operation began at 1900 hours on 28 May and continued through 1100 hours on 26 July. Data collection procedures were the same as those used in past years (Bucher 1980). Smolt counting was conducted 24 hours per day as was done in 1982 (Bucher 1984). Array I was designated as the index array and operated continuously throughout the season. The other three arrays were operated in random sequence of 15 minute intervals each hour. Hourly counts for Arrays II, III, and IV were estimated by expanding 15 minute counts obtained for each array.

Counting rate of the sonar system was a function of water velocity, which, for Wood River, fluctuated continually with the flood and ebb of the tide. Therefore, counting rate settings were adjusted as changes in water velocity occurred using information obtained from a remote digital indicator connected to a current meter installed in the river channel behind Array I. To determine whether different water velocity corrections were needed for the other arrays, flow measurements were made behind each of the other arrays, when tidal influence was minimal, once during each five day sampling period. The ratio of water velocity over each of these arrays to that over Array I was used to adjust counts obtained from Arrays II, III, and IV.

Sonar counts were also adjusted to account for smolt migrating through sections of the counting site transect not covered by sonar. Expansion factors used for 1983 data analysis were 5.35, 3.74, 4.05, and 8.12 for Arrays I, II, III, and IV, respectively. After these corrections were made, counts from each array were summed to yield a total daily count.

Finally, the total daily count was multiplied by the estimated number of smolt required to produce each sonar count, since the sonar system was designed to count biomass rather than individual smolt. In past studies, adjusted sonar counts were multiplied by a factor of five to obtain final estimates of smolt numbers because the sonar system was set at the factory to register one count for the equivalent of five smolt, each weighing 8.29975 g. However, because mean smolt weight varied during the season as well as among years, more accurate final estimates of smolt numbers were obtained in 1983 by using actual mean smolt weight data from daily fyke net catches to expand counts. Since the historical mean weight for Wood River smolt (5.37 g) was 2.93 g less than that used for the factory setting, smolt abundance estimates had been underestimated by about 35% prior to 1983. Corrections for actual mean smolt weight will be made in subsequent reports for all available years of data.

Smolt samples were obtained by fishing with a fyke net. About 60 smolt per sampling day were wet weighed in g, measured for fork length in mm, and aged from scale samples. Daily data were combined to obtain samples of about 400 smolt (usually obtained in seven sampling days) for estimating age class composition. This sample size was large enough to produce estimates of the proportion of age I or age II smolt which were within 5% of the actual proportion (at the 0.05 significance level for age class proportions ranging from 0.05 to 0.95) (Cochran 1963).

Smolt from daily samples were also examined externally for the presence of *T. crassus*. Percent infection of age I and age II smolt by this parasite was calculated by five-day periods. Smolt population estimates for each five-day were used as weighting factors for calculating percent infection.

RESULTS AND DISCUSSION

A total of 857,724 sonar counts were recorded during the season (Table 1). Counts generally decreased from the north bank to the south bank of the transect with most counts recorded over Array I (about 32% of season total)

and fewest counts recorded over Array IV (about 15% of season total). This pattern was similar to that recorded for past years (Table 2).

Estimated total numbers of smolt migrating seaward was 23,728,252 (Table 3). The migration began on 18 May, soon after ice went out of Lake Aleknagik, and about 50% of the total smolt population had migrated past the sonar site by 28 June.

A total of 3,488 smolt were sampled to obtain data on age, length, and weight (Table 4). Age class composition of the total smolt population was estimated to be 82.6% age I (1981 brood year) and 17.4% age II (1980 brood year). Mean lengths of age I and II smolt were 86 mm and 97 mm, respectively. Mean weights of age I and II smolt were 6.5 g and 9.2 g, respectively. Mean lengths and weights of both age classes were greater than the grand means for 1975-1982 (Table 5). In contrast to east side Bristol Bay systems, mean smolt weight tended to increase as the season progressed, resulting in decreased numbers of smolt per sonar count later in the season (Table 6).

Infection by *T. crassus* was greater in nonstatistical comparisons (NSC) for age II (73.6%) than for age I (43.1%) smolt (Table 7). The incidence of infection within individuals of both age classes decreased (NSC) as the season progressed. Mean percent infection for both age classes was greater (NSC) than that observed in past years (Table 8).

Smolt numbers in 1983 were the lowest recorded since the sonar project began (range, 1975-1982, 33,850,000 to 106,200,000) (Table 5). Although smolt abundance and timing early in the season appeared to be about average, abundance did not increase as the season progressed, and by 1 July it was evident that total numbers of smolt would be very low (Table 3). Since abundance of age I smolt was low in 1982, it was hoped that most of the progeny from the 1980 brood year spawning escapement had remained within the system for a second growing season and would migrate to sea in 1983 as age II smolt (Bucher 1984). The 1980 spawning escapement of 2.97 million was the largest ever recorded for Wood River system, but only produced 12.28 smolt per spawner (32,350,000 age I smolt migrated to sea in 1982; 4,130,000 migrated to sea in 1983) (Table 9). This was the lowest smolt production recorded since the sonar program began (range, 1972-1979 brood years, 35.02 to 112.19 smolt per spawner). Average marine survival for smolt produced by the 1972-1979 brood years has been about 6% for both age I and age II smolt (i.e. an average of 0.06 adults have returned for each age I smolt produced) (Table 10).

Water temperature and lake depth measurements were recorded daily at Lake Aleknagik outlet from 28 May until 20 July (Table 11). Minimum and maximum daily water temperatures were recorded on 31 May (4.4^{o}C) and 4 July (12.8^{o}C), respectively. Minimum and maximum lake depths were recorded on 20 July (0.46 m) and 4-8 June (1.19 m), respectively. Mean water temperature and lake depth for the season were 8.7^{o}C and 0.90 m, respectively, which were similar to the grand means 1975-1982 (Table 12).

LITERATURE CITED

Bucher, W. 1980. 1979 Wood River sockeye salmon smolt studies. Pages 12-33 in C.P. Meacham, editor. 1979 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 46, Juneau, Alaska.

Bucher, W. 1981. 1980 Wood River sockeye salmon smolt studies. Pages 16-33 in C.P. Meacham, editor. 1980 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 63, Juneau, Alaska.

Bucher, W. 1982. 1981 Wood River sockeye salmon smolt studies. Pages 24-48 in D.C. Huttunen, editor. 1981 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 73, Juneau, Alaska.

Bucher, W. 1984. 1982 Wood River sockeye salmon smolt studies. Pages 47-68 in D.M. Eggers and H.J. Yuen, editors. 1980 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 103, Juneau, Alaska.

Church, W. 1963. Red salmon smolts from the Wood River system, 1961. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 32, Juneau, Alaska.

Church, W., and M. Nelson. 1963. Abundance, size and age of red salmon smolts from the Wood River system, 1962. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 33, Juneau, Alaska.

Clark, J.H., and T.L. Robertson. 1980. 1978 Wood River sockeye salmon smolt studies. Pages 18-29 in C.P. Meacham, editor. 1978 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 44, Juneau, Alaska.

Cochran, W.G. 1963. Sampling Techniques. Second Edition. John Wiley and Sons, New York, New York, USA.

Krasnowski, P. 1976. 1975 Wood River sockeye salmon smolt studies. Pages 29-51 in P. Krasnowski, editor. 1975 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 25, Juneau, Alaska.

Krasnowski, P. 1977. 1976 Wood River sockeye salmon smolt studies. Pages 24-43 in N. Newcome, editor. 1976 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 33, Juneau, Alaska.

Nelson, M.L. 1964. Abundance, size and age of red salmon smolts from the Wood River system, 1963. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 37, Juneau, Alaska.

Nelson, M.L. 1965. Abundance, size and age of red salmon smolts from the Wood River system, 1964. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 54, Juneau, Alaska.

Nelson, M.L. 1966. Abundance, size and age of red salmon smolts from the Wood River system, 1965. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 76, Juneau, Alaska.

Newcome, N. 1978. 1977 Wood River sockeye salmon studies. Pages 24-34 in H. Yuen, editor. 1977 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 41, Juneau, Alaska.

Siedelman, D.L. 1967. Abundance, size and age of red salmon smolts from the Wood River Lakes system, 1966. Pages 18-33 in D.M. Stewart, editor. 1966 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 102, Juneau, Alaska.

Table 1. Sonar counts recorded from four 10 transducer arrays at the sockeye salmon smolt counting site on the Wood River, Bristol Bay, Alaska, 1983. False counts were deleted, and interpolations were made for time missed when sonar not operated.

Date a/	Sonar Counts: Transducer Array I	II	III	IV	Total
5 28	354	1,035	570	230	2,189
5 29	2,008	2,918	1,824	1,046	7,796
5 30	990	2,162	1,020	644	4,816
5 31	3,154	4,038	4,856	2,088	14,136
6 1	15,236	5,036	3,088	1,740	25,100
6 2	7,849	5,332	2,568	2,742	18,491
6 3	9,663	9,107	2,742	1,690	23,202
6 4	5,420	4,988	2,420	1,404	14,232
6 5	4,385	2,510	950	820	8,665
6 6	2,867	2,344	1,252	1,162	7,615
6 7	2,905	2,724	1,644	790	8,063
6 8	4,883	3,184	1,376	598	10,041
6 9	4,584	5,926	3,878	1,308	15,696
6 10	3,204	7,308	2,674	728	13,914
6 11	3,589	2,720	2,034	694	9,037
6 12	3,994	1,820	816	426	7,056
6 13	2,697	2,484	1,516	676	7,373
6 14	2,382	2,764	720	416	6,282
6 15	5,557	5,142	2,354	1,530	14,583
6 16	2,071	3,380	2,170	1,005	8,626
6 17	1,492	2,401	2,181	1,138	7,212
6 18	2,850	3,758	5,126	969	12,703
6 19	3,753	5,598	4,392	2,117	15,860
6 20	6,713	4,214	1,348	850	13,125
6 21	7,238	5,402	1,308	1,660	15,608
6 22	3,655	7,106	3,760	1,992	16,513
6 23	2,741	5,104	3,918	2,182	13,945
6 24	3,537	3,634	3,761	1,672	12,604
6 25	2,242	3,326	3,187	1,921	10,676
6 26	7,968	4,324	1,718	1,400	15,410
6 27	7,399	3,332	1,390	972	13,093
6 28	8,846	8,430	8,194	3,836	29,306
6 29	4,238	4,358	5,946	4,300	18,842
6 30	4,687	4,150	5,986	5,364	20,187
7 1	2,233	2,540	11,484	780	17,037
7 2	1,763	2,646	1,726	2,090	8,043

-Continued-

Table 1. Sonar counts recorded from four 10 transducer arrays at the sockeye salmon smolt counting site on the Wood River, Bristol Bay, Alaska, 1983. False counts were deleted, and interpolations were made for time missed when sonar not operated (continued).

	Sonar Counts				
	Transducer Array				
Date a/	I	II	III	IV	Total
7 3	4,242	1,968	7,640	2,196	16,046
7 4	6,369	6,616	3,478	5,990	22,453
7 5	6,422	6,116	4,472	2,698	19,708
7 6	13,196	5,976	3,194	3,908	26,274
7 7	5,328	3,414	6,428	3,756	18,926
7 8	2,736	5,638	3,442	5,217	17,033
7 9	5,892	7,628	5,928	3,762	23,210
7 10	9,597	5,652	7,620	2,690	25,559
7 11	11,627	7,510	4,506	2,506	26,149
7 12	4,597	3,761	3,270	2,580	14,208
7 13	6,539	3,496	3,264	3,066	16,365
7 14	3,965	7,202	4,920	1,550	17,637
7 15	2,985	2,592	4,698	2,966	13,241
7 16	4,173	3,370	2,236	4,178	13,957
7 17	1,441	3,386	3,452	2,212	10,491
6 18	2,074	3,460	2,738	3,688	11,960
7 19	2,750	3,954	3,548	2,680	12,932
7 20	3,126	6,290	5,198	4,670	19,284
7 21	2,569	2,309	3,542	2,726	11,146
7 22	2,833	7,019	4,544	4,592	18,988
7 23	3,380	7,135	3,387	2,092	15,994
7 24	3,323	2,802	1,629	2,844	10,598
7 25	2,436	2,458	2,190	1,404	8,488
Total	270,747	256,805	201,221	128,951	857,724
Percent	31.57	29.94	23.46	15.03	100.00

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 2. Percentage of total unexpanded sonar counts recorded over each array, Wood River, Bristol Bay, Alaska, 1975-1983. False counts were deleted, and interpolations were made for time missed when sonar not operated.

	Percentage of Sonar Counts				
	Transducer Array				
Year	I	II	III	IV	References
1975 a/	68.6	31.4	-	-	Krasnowski (1976)
1976	49.0	30.2	11.7	9.1	Krasnowski (1977)
1977	36.0	24.4	20.8	18.8	Newcome (1978)
1978	28.6	29.7	25.6	16.1	Clark and Robertson (1980)
1979	17.0	27.1	33.1	22.8	Bucher (1980)
1980	34.1	35.2	20.5	10.2	Bucher (1981)
1981	39.2	24.8	24.9	11.1	Bucher (1982)
1982	38.2	31.3	15.9	14.6	Bucher (1984)
Mean b/	34.6	29.0	21.8	14.7	
1983	31.6	29.9	23.5	15.0	

a/ Only two transducer arrays used.
b/ Data for 1975 omitted.

Table 3. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Wood River, Bristol Bay, Alaska, 1983.

	Age I		Age II		All Ages	
Date a/	Number	Percent	Number	Percent	Daily Total	Cumulative Total
5 28	22,054	32.97	44,837	67.03	66,892	66,892
5 29	73,885	32.97	150,213	67.03	224,099	290,991
5 30	42,911	32.97	87,241	67.03	130,152	421,143
5 31	110,440	32.97	224,531	67.03	334,972	756,116
6 1	214,779	32.97	436,658	67.03	651,437	1,407,554
6 2	182,839	32.97	371,723	67.03	554,562	1,962,116
6 3	221,692	32.97	450,715	67.03	672,408	2,634,524
6 4	362,873	70.63	150,903	29.37	513,777	3,148,301
6 5	207,030	70.63	86,095	29.37	293,125	3,441,427
6 6	196,064	70.63	81,535	29.37	277,599	3,719,027
6 7	241,522	70.63	100,438	29.37	341,961	4,060,988
6 8	231,050	70.63	96,083	29.37	327,133	4,388,122
6 9	370,290	70.63	153,988	29.37	524,278	4,912,401
6 10	289,527	70.63	120,402	29.37	409,930	5,322,331
6 11	244,836	74.32	84,580	25.68	329,416	5,651,748
6 12	143,982	74.32	49,739	25.68	193,722	5,845,470
6 13	146,951	74.32	50,765	25.68	197,716	6,043,187
6 14	146,166	74.32	50,494	25.68	196,660	6,239,847
6 15	332,612	74.32	114,902	25.68	447,515	6,687,363
6 16	208,461	74.32	72,014	25.68	280,476	6,967,839
6 17	192,556	74.32	66,519	25.68	259,076	7,226,915
6 18	203,441	77.93	57,615	22.07	261,056	7,487,972
6 19	259,715	77.93	73,552	22.07	333,267	7,821,240
6 20	300,433	77.93	85,083	22.07	385,516	8,206,756
6 21	370,701	77.93	104,983	22.07	475,685	8,682,442

-Continued-

Table 3. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Wood River, Bristol Bay, Alaska, 1983 (continued).

Date a/	Age I		Age II		All Ages	
	Number	Percent	Number	Percent	Daily Total	Cumulative Total
6 22	418,433	77.93	118,501	22.07	536,934	9,219,377
6 23	475,144	88.76	60,169	11.24	535,313	9,754,690
6 24	366,280	88.76	46,383	11.24	412,664	10,167,354
6 25	220,896	88.76	27,972	11.24	248,869	10,416,224
6 26	376,591	88.76	47,689	11.24	424,281	10,840,505
6 27	244,637	88.76	30,979	11.24	275,616	11,116,122
6 28	777,546	88.76	98,463	11.24	876,010	11,992,132
6 29	434,085	94.30	26,224	5.70	460,310	12,452,442
6 30	739,396	94.30	44,669	5.70	784,066	13,236,508
7 1	465,862	94.30	28,144	5.70	494,006	13,730,514
7 2	206,730	94.30	12,489	5.70	219,220	13,949,735
7 3	355,557	94.30	21,480	5.70	377,037	14,326,772
7 4	567,144	94.30	34,263	5.70	601,407	14,928,179
7 5	522,823	94.30	31,585	5.70	554,408	15,482,588
7 6	646,478	94.30	39,055	5.70	685,534	16,168,123
7 7	580,834	98.62	8,107	1.38	588,942	16,757,065
7 8	554,726	98.62	7,743	1.38	562,470	17,319,535
7 9	657,973	98.62	9,184	1.38	667,158	17,986,693
7 10	692,497	98.62	9,666	1.38	702,163	18,688,856
7 11	578,122	98.62	8,069	1.38	586,192	19,275,049
7 12	336,347	98.62	4,695	1.38	341,042	19,616,091
7 13	390,971	98.62	5,457	1.38	396,428	20,012,520
7 14	372,716	98.62	5,202	1.38	377,919	20,390,440
7 15	318,773	98.62	4,449	1.38	323,222	20,713,663
7 16	343,566	98.62	4,795	1.38	348,361	21,062,025

-Continued-

Table 3. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Wood River, Bristol Bay, Alaska, 1983 (continued).

	Age I		Age II		All Ages	
Date a/	Number	Percent	Number	Percent	Daily Total	Cumulative Total
7 17	211,171	98.62	2,947	1.38	214,118	21,276,143
7 18	304,004	98.78	3,760	1.22	307,765	21,583,909
7 19	304,770	98.78	3,770	1.22	308,540	21,892,450
7 20	427,906	98.78	5,293	1.22	433,200	22,325,650
7 21	246,378	98.78	3,047	1.22	249,426	22,575,076
7 22	421,270	98.78	5,211	1.22	426,482	23,001,559
7 23	278,223	98.78	3,441	1.22	281,665	23,283,224
7 24	244,273	98.78	3,021	1.22	247,295	23,530,520
7 25	195,315	98.78	2,416	1.22	197,731	23,728,252

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Wood River, Bristol Bay, Alaska, 1983.

	Age I					Age II				
Date a/	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5 28	76	1.7	3.5	0.17	14	92	0.7	6.9	0.13	30
5 29	78	1.8	5.0	0.34	22	86	1.4	7.3	0.27	38
5 30	78	0.7	5.3	0.14	22	89	0.9	7.7	0.21	38
5 31	81	2.3	6.2	0.46	10	92	0.6	8.3	0.16	50
6 1	76	4.2	5.5	0.28	18	92	0.7	7.9	0.16	42
6 2	76	0.8	4.7	0.18	22	89	0.8	7.5	0.17	37
6 3	79	1.0	4.8	0.19	25	89	0.8	7.2	0.20	35
6 4	76	0.6	4.4	0.13	42	88	1.3	6.6	0.27	18
6 5	78	0.7	4.8	0.10	36	86	0.8	6.6	0.17	24
6 6	77	0.6	4.8	0.11	41	87	1.4	6.5	0.37	19
6 7	74	0.6	4.1	0.08	51	86	1.0	6.4	0.41	5
6 8	79	0.7	4.9	0.12	48	89	1.5	6.8	0.32	24
6 9	80	0.6	4.8	0.11	41	89	1.4	6.5	0.30	19
6 10	81	0.8	4.9	0.13	42	96	1.0	7.9	0.20	18
6 11	81	0.5	4.7	0.09	52	93	2.5	7.1	0.74	8
6 12	81	1.0	5.1	0.19	33	98	1.3	8.7	0.33	26
6 13	82	0.8	5.5	0.14	33	97	1.1	8.5	0.28	27
6 14	81	0.9	5.1	0.08	94	96	1.0	7.7	0.24	26
6 15	80	1.0	4.8	0.22	33	97	0.8	8.3	0.28	18
6 16	84	0.9	5.3	0.17	35	96	2.7	7.7	0.50	5
6 17	81	0.6	5.1	0.12	82	94	2.7	7.6	0.50	7
6 18	91	1.5	7.9	0.32	47	103	1.2	10.9	0.37	15
6 19	89	1.5	6.6	0.41	23	105	0.8	10.3	0.18	35
6 20	83	0.5	5.9	0.13	129	97	1.5	9.0	0.38	13
6 21	85	0.6	5.9	0.12	106	96	1.3	7.7	0.44	14

-Continued-

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Wood River, Bristol Bay, Alaska, 1983 (continued).

	Age I					Age II				
Date a/	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
6 22	81	0.6	5.4	0.07	152	98	1.6	9.1	0.50	8
6 23	81	0.6	4.8	0.11	54	100	0.0	8.3	0.00	1
6 24	86	1.7	5.7	0.46	10	-				0
6 25	-		-		0	-				0
6 26	88	0.7	6.3	0.14	50	101	2.0	9.4	0.57	10
6 27	89	0.6	8.0	0.15	120	101	0.8	10.9	0.23	49
6 28	85	0.4	6.1	0.09	136	96	3.7	8.5	1.10	13
6 29	-		-		0	-				0
6 30	84	1.1	5.4	0.20	11	-				0
7 1	86	0.8	5.9	0.19	27	-				0
7 2	91	1.5	7.2	0.23	10	110	0.0	11.7	0.00	1
7 3	93	0.5	7.7	0.13	106	104	2.1	11.1	0.49	13
7 4	89	0.9	7.7	0.14	110	100	3.7	10.5	1.12	7
7 5	89	2.1	6.7	0.49	8	99	0.0	7.4	0.00	1
7 6	90	0.3	7.4	0.07	175	110	2.3	12.6	0.49	5
7 7	89	3.5	6.4	0.82	4	-				0
7 8	87	1.2	6.4	0.45	3	-				0
7 9	89	0.5	6.7	0.14	7	-				0
7 10	90	3.4	6.8	0.75	8	-				0
7 11	-		-		0	-				0
7 12	92	0.4	8.0	0.12	167	111	2.3	12.9	0.84	8
7 13	92	0.6	8.2	0.16	69	107	2.5	12.7	0.65	2
7 14	93	1.1	8.3	0.22	24	-				0
7 15	-		-		0	-				0
7 16	92	0.6	8.7	0.21	82	-				0

-Continued-

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Wood River, Bristol Bay, Alaska, 1983 (continued).

	Age I					Age II				
Date a/	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
7 17	92	2.1	9.4	0.20	57	110	1.5	13.8	0.52	3
7 18	-		-		0	-				0
7 19	-		-		0	-				0
7 20	93	0.4	9.0	0.11	59	97	0.0	10.0	0.00	1
7 21	93	0.7	9.2	0.19	44	-				0
7 22	94	0.6	9.0	0.23	45	93	0.0	8.7	0.00	1
7 23	95	0.4	10.3	0.14	86	107	7.0	14.3	2.90	2
7 24	92	0.6	9.0	0.16	47	-				0
Totals					2,772					716
Means	86		6.5			97		9.2		

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 5. Age composition of total migration, and mean fork length (mm) and weight (g) by age class, for sockeye salmon smolt, Wood River, Bristol Bay, Alaska, 1951-1983. A dash (-) indicates data not available.

Year of Migration	Age I			Age II			Total Estimate	References
	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)		
1951 a/	80.1	91	-	20.0	-	-	-	Univ. Washington (unpub)
1952	99.0	87	-	1.0	-	-	-	"
1953	95.3	86	-	4.7	103	-	-	"
1954	95.8	87	-	4.2	107	-	-	"
1955	98.0	85	-	2.0	102	-	-	"
1956	78.4	82	-	21.6	95	-	-	"
1957	80.7	77	-	19.3	93	-	-	"
1958	65.0	82	-	35.0	102	-	-	"
1959	93.5	88	-	6.5	105	-	-	"
1960	99.4	88	-	0.6	114	-	-	"
1961	93.0	82	-	7.0	102	-	-	Church (1963)
1962	86.0	80	-	14.0	98	-	-	Church and Nelson (1963)
1963	84.3	83	-	15.7	102	-	-	Nelson (1964)
1964	98.8	84	-	1.2	104	-	-	Nelson (1965)
1965	92.0	86	-	8.0	106	-	-	Nelson (1966)
1966	94.3	77	-	5.7	101	-	-	Siedelman (1967)
1975 b/	86.0	83	-	14.0	98	-	33,850,000	Krasnowski (1976)
1976	95.5	84	-	4.5	95	-	106,200,000	Krasnowski (1977)
1977	82.9	71	3.5	17.1	98	9.3	73,300,000	Newcome (1978)
1978	84.7	79	-	15.3	90	-	55,000,000	Clark and Robertson (1980)
1979	92.2	90	7.6	7.8	100	10.1	65,970,000	Bucher (1980)
1980	96.0	78	4.0	4.0	95	6.8	48,300,000	Bucher (1981)

-Continued-

Table 5. Age composition of total migration, and mean fork length (mm) and weight (g) by age class, for sockeye salmon smolt, Wood River. Bristol Bay, Alaska, 1951-1983. A dash (-) indicates data not available (continued).

Year of Migration	Age I Percent of Total Estimate	Age I Mean Length (mm)	Age I Mean Weight (g)	Age II Percent of Total Estimate	Age II Mean Length (mm)	Age II Mean Weight (g)	Total Estimate	References
1981	66.1	88	6.3	33.9	96	8.4	97,530,000	Bucher (1982)
1982	87.3	79	4.7	12.7	98	8.4	37,060,000	Bucher (1984)
Mean		80	5.2		96	8.6		
1983 c/	82.6	86	6.5	17.4	98	9.2	23,730,000	

a/ Fyke net catches used to index abundance of smolt, 1951-1966.
b/ Sonar equipment used to estimate numbers of smolt, age composition was estimated by weighting sample period age composition estimates by estimated smolt numbers for the same period. Sonar counts were not adjusted for smolt size.
c/ Sonar equipment used to estimate numbers of smolt, age composition was estimated by weighting sample period age composition estimates by estimated smolt numbers for the same period. Sonar counts were adjusted for smolt size.

Table 6. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Wood River, Bristol Bay, Alaska, 1983.

Date a/	Mean Weight of smolt	Smolt per Count
5 28	5.8	7.1
5 29	6.5	6.4
5 30	6.8	6.1
5 31	8.0	5.2
6 1	7.2	5.8
6 2	6.5	6.4
6 3	6.2	6.7
6 4	5.1	8.1
6 5	5.5	7.5
6 6	5.5	7.8
6 7	5.3	9.6
6 8	4.3	7.5
6 9	5.6	7.7
6 10	5.4	7.2
6 11	5.8	8.3
6 12	5.0	6.2
6 13	6.7	6.1
6 14	6.8	7.3
6 15	5.7	6.9
6 16	6.0	7.4
6 17	5.6	7.9
6 18	5.3	4.8
6 19	8.6	4.7
6 20	8.6	6.7
6 21	6.2	6.8
6 22	5.6	7.4
6 23	4.9	8.5
6 24	5.7	7.2
6 25	no sample	5.0
6 26	6.8	6.1
6 27	8.8	4.7
6 28	6.3	6.6
6 29	no sample	5.0
6 30	5.4	7.7
7 1	5.9	7.0
7 2	7.6	5.5
7 3	8.1	5.1
7 4	7.8	5.3
7 5	6.7	6.2
7 6	7.5	5.5
7 7	6.4	6.5
7 8	6.4	6.5
7 9	6.7	6.2

-Continued-

Table 6. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Wood River, Bristol Bay, Alaska, 1983 (continued).

Date a/	Mean Weight of smolt	Smolt per Count
7 10	6.8	6.1
7 11	no sample	5.0
7 12	8.2	5.1
7 13	8.3	5.0
7 14	8.3	5.0
7 15	no sample	5.0
7 16	8.7	4.8
7 17	9.6	4.3
7 18	no sample	5.0
7 19	no sample	5.0
7 20	9.0	4.6
7 21	9.2	4.5
7 22	9.0	4.6
7 23	10.4	4.0
7 24	9.0	4.6
7 25	no sample	5.0

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 7. Infection of sockeye salmon smolts by the cestode Triaenophorus crassus, Wood River, Bristol Bay, Alaska, 1983. Infection determined by gross external examination.

	Age I		Age II	
Sample Period	Number Examined	Percent Infected	Number Examined	Percent Infected
28 May- 1 June	86	65.1	198	81.8
2- 6 June	166	45.8	133	81.2
7-11 June	234	47.4	74	81.1
12-16 June	228	50.0	102	65.7
17-21 June	387	55.3	84	65.5
22-27 June	386	56.5	68	47.1
28 June- 3 July	290	43.8	27	51.9
4- 8 July	300	38.7	13	38.5
9-14 July	275	39.3	10	20.0
15-21 July	242	27.7	4	25.0
22-25 July	178	22.5	3	66.7
Means		43.1		73.6

Table 8. Infection of sockeye salmon smolt by the cestode Trianophorus crassus, Wood River, Bristol Bay, Alaska, 1978-1983.

Year	Percent Infected		References
	Age I	Age II	
1978	15.1	40.5	Clark and Robertson (1980)
1979	10.0	30.8	Bucher (1980)
1980	11.1	17.3	Bucher (1981)
1981	28.2	35.6	Bucher (1982)
1982	10.0	21.2	Bucher (1984)
Mean	14.9	29.1	
1983	43.1	73.6	

Table 9. Sockeye salmon spawning escapements, total number of smolt produced by age class (percent of total smolt production comprised by each age class indicated within parentheses), and number of smolt produced per spawner for 1972-1981 brood years, Wood River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total Spawning Escapement	Number of Smolt Produced			
		Age I	Age II	Total	Per Spawner
1972	430,000	-	5,900,000	-	-
1973	330,000	27,950,000 (85)	4,800,000 (15)	32,750,000	99.24
1974	1,710,000	101,400,000 (89)	12,550,000 (11)	113,950,000	66.64
1975	1,270,000	60,750,000 (88)	8,400,000 (12)	69,150,000	54.45
1976	820,000	46,600,000 (90)	5,130,000 (10)	51,730,000	63.09
1977	560,000	60,840,000 (97)	1,930,000 (3)	62,770,000	112.19
1978	2,270,000	46,370,000 (58)	33,200,000 (42)	79,570,000	35.02
1979	1,710,000	64,330,000 (93)	4,710,000 (7)	69,040,000	40.37
1980	2,970,000	32,350,000 (89)	4,130,000 (11)	36,480,000	12.28
1981	1,230,000	19,590,000			

Table 10. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1972-1981 brood years, Wood River, Bristol Bay, Alaska. A dash (-) indicates data not available.

Brood Year	Total Spawning Escapement	Age I			Age II		
		Number of Smolt	Adult Returns	Adult Returns per Smolt	Number of Smolt	Adult Returns	Adult Returns per Smolt
1972	430,000	-	1,411,551	-	5,900,000	55,771	0.01
1973	330,000	27,950,000	1,334,355	0.05	4,800,000	102,717	0.02
1974	1,710,000	101,400,000	4,574,242	0.05	12,550,000	478,861	0.04
1975	1,270,000	60,750,000	3,576,900	0.06	8,400,000	1,110,878	0.13
1976	820,000	46,600,000	4,744,923	0.10	5,130,000	826,181	0.16
1977	560,000	60,840,000	3,382,204	0.06	1,990,000	91,247	0.05
1978	2,270,000	46,300,000	2,485,803	0.05 a/	33,200,000	741,426	0.02 a/
1979	1,710,000	64,330,000	2,818,000	0.04 a/	4,710,000		
1980	2,970,000	32,350,000			4,130,000		
1981	1,230,000	19,590,000					

a/ Future adult returns will increase these values.

Table 11. Water temperatures and depths,at field camp site, head of Wood River (outlet of Lake Aleknagik), Bristol Bay, Alaska, 1983.

	Mean Water Temp. (C)	Mean Water Depth (m)
5 27	-	-
5 28	6.7	0.98
5 29	5.6	0.98
5 30	5.6	1.04
5 31	4.4	1.10
6 1	5.6	1.13
6 2	6.1	1.16
6 3	6.1	1.16
6 4	5.6	1.19
6 5	6.1	1.19
6 6	7.2	1.19
6 7	7.2	1.19
6 8	7.2	1.19
6 9	7.8	1.17
6 10	7.8	1.17
6 11	8.9	1.16
6 12	6.7	1.16
6 13	5.6	1.16
6 14	6.7	1.16
6 15	7.2	1.16
6 16	7.8	1.11
6 17	10.0	1.10
6 18	9.4	1.10
6 19	9.4	1.04
6 20	7.2	1.04
6 21	6.1	1.01
6 22	7.2	0.98
6 23	7.2	0.94
6 24	7.8	0.91
6 25	8.9	0.91
6 26	8.9	0.88
6 27	8.9	0.91
6 28	7.2	0.88
6 29	7.8	0.85
6 30	8.9	0.85
7 1	10.0	0.82
7 2	11.1	0.79
7 3	11.7	0.79
7 4	12.8	0.76
7 5	11.7	0.73
7 6	11.1	0.70
7 7	9.4	0.64

-Continued-

Table 11. Water temperatures and depths,at field camp site, head of Wood River (outlet of Lake Aleknagik), Bristol Bay, Alaska, 1983 (continued).

	Mean Water Temp. (C)	Mean Water Depth (m)
7 8	8.9	0.61
7 9	9.4	0.64
7 10	8.9	0.64
7 11	9.4	0.61
7 12	10.6	0.64
7 13	11.1	0.64
7 14	12.2	0.61
7 15	12.8	0.61
7 16	12.8	0.61
7 17	12.8	0.58
7 18	12.8	0.55
7 19	12.8	0.49
7 20	12.8	0.46
Mean	8.7	0.90

Table 12. Water temperatures and depths at field camp site, head of Wood River (outlet of Lake Aleknagik), Bristol Bay, Alaska, 1975-1983. A dash (-) indicates missing data.

Year	Sample Period	Water Temperature (C)			Water Depth (m)			References
		Minimum	Maximum	Mean	Minimum	Maximum	Mean	
1975	29 May-19 July	2.0	9.5	5.0	-0.24	0.57	0.37	Krasnowski (1976)
1976	9 June- 7 August	2.0	14.0	8.0	0.24	1.07	0.57	Krasnowski (1977)
1977	9 June- 8 August	4.5	15.5	9.0	-	-	1.52	Newcome (1978)
1978	28 May- 9 August	5.0	16.0	9.0	0.37	0.98	0.82	Clark and Robertson (1980)
1979	30 May- 2 August	4.5	16.0	9.0	0.33	1.46	0.93	Bucher (1980)
1980	30 May-15 August	4.5	18.0	9.0	0.34	1.65	1.07	Bucher (1981)
1981	27 May-13 August	5.4	17.5	11.4	0.03	1.21	0.55	Bucher (1982)
1982	27 May-10 August	2.2	12.0	6.4	0.46	1.62	1.17	Bucher (1984)
	Mean	3.8	14.8	8.4	0.22	1.22	0.88	
1983	28 May-26 July	4.4	12.8	8.7	0.46	1.19	0.90	

NUYAKUK RIVER SOCKEYE SALMON SMOLT STUDIES FOR 1983

By

R. Eric Minard and Mark Frederickson
Alaska Department of Fish and Game
Division of Commercial Fisheries
Dillingham, Alaska

INTRODUCTION

The Nuyakuk River is a major tributary of the Nushagak River and typically accounts for 83% of the sockeye salmon production from the Nushagak system. This was the first year a sonar counter was used on the Nuyakuk River to estimate numbers of smolt. In 1982, fyke nets were fished to collect age, weight, and length data for smolt produced from the highest recorded spawning escapement of 3.0 million sockeye salmon in 1980 (Minard 1984).

Major objectives of the Nuyakuk River smolt project were 1) to estimate numbers of seaward migrating sockeye salmon smolt, 2) to describe smolt migration patterns, 3) to determine the age, length, and weight composition of the smolt population, and 4) to record climatological and hydrological parameters which might affect migratory behavior. This data will be used to forecast future returns of adult sockeye salmon to the Nuyakuk system and to aid in evaluating spawning escapement goals.

MATERIALS AND METHODS

Based upon results of the 1982 site selection study (Minard 1984), sonar equipment was placed about 3.5 km downriver from the outlet of Tikchik Lake. The river at this site was about 150 m wide and had a maximum depth of 5.0 m. Water velocity during the 1983 smolt migration ranged between 0.70 and 1.15 m/sec.

The sonar system was designed and built by Bendix Corporation in 1982. Equipment consisted of three 3.05 m long ladder-shaped arrays, each housing 10 upward-facing transducers, connected to a single control unit. The offshore array was anchored in the Nuyakuk River on 26 May, while the center and inshore arrays were anchored in the river the following day. Inshore, center, and offshore arrays were situated 21, 48, and 70 m, respectively from the south bank of the rivers at the counting site where the control unit was housed in a canvas wall tent.

Counting operations began at 1900 hrs on 27 May and continued until 1200 hrs on 1 July. Although return echoes were automatically printed by the control unit every hour, the sonar system was monitored continuously by field personnel during the entire project so that false counts (due to entrained air from wind, rain, ice, etc.) could be recorded and the counter disabled when the frequency of false counts became very high (e.g. during periods of

high winds or heavy rain). At the end of each day, false counts were subtracted from total recorded sonar counts, and counts were estimated by interpolation during times when the sonar system was disabled.

A General Oceanics Model 2031 flow meter was suspended about 0.5 m below the water surface directly behind the inshore array. Since counting rate of the sonar systems depended upon residence time of smolt within transducer beams, which was a function of river velocity as well as smolt swimming speed, current speed data from the meter was used to adjust the current speed setting on the sonar unit after each hourly printing interval. Counts from the other two arrays were further adjusted during final calculations for any differences in current speeds across the counting transect. This was determined from current speed measurements made behind the center and offshore arrays several times during the season. Current speeds over the center and offshore arrays were only 1.050 and 1.011, respectively, greater than those recorded over the inshore array.

Sonar counts were also adjusted to account for smolt migrating through sections of the river not covered by the three transducer arrays. These adjustments were made using data obtained with a side-scanning sonar counter, built by Bendix Corporation in 1975. These data indicated that the inshore and offshore limits of smolt distribution were 3.05 and 117.35 m, respectively.

A 1.2-m x 2.1-m fyke net was fished in 1.5 m of water about 1 km upriver from the sonar site. About 60 smolt per sampling day were wet weighed in g, measured for fork length in mm, and aged from scale samples. While no attempt was made to increase daily sample sizes, as was done for river systems on the east side of Bristol Bay, daily data were combined to obtain samples of about 240 smolt (i.e. total catch for a four to seven day period) for estimating age class composition and mean weight. Since past data indicated that age I smolt generally comprised over 80% of the smolt population during any migration year (1978, 81.1% age I; 1982, 99.6% age I), a sample of about 240 smolt was large enough to produce estimates of the proportion of age I or age II smolt which were within 5% of the actual proportion (at the 0.05 significance level for actual age class proportions ranging from 0.20 to 0.80) (Cochran 1963). Mean weight of at least 240 smolt were used to adjust sonar counts after the season, since the sonar system was set at the factory to register one count for the biomass equivalent of five smolt having a mean weight of 8.29975 g.

Climatological and hydrological conditions were recorded daily at the sonar site. Subjective observations were made of cloud cover, wind velocity, and river turbidity, while air and water temperature and precipitation were measured at 0800 and 2000 hrs.

RESULTS AND DISCUSSION

A total of 402,268 sonar counts were recorded during 27 May until 30 June 1983 (Table 1). About 51% of these counts occurred over the inshore, 29% over the center, and 20% over the offshore array (Table 1). The final total smolt migration estimate was 30,134,497 (Table 2). Age class composition was 96%

age I (28,875,158) and 4% age II (1,259,339) smolt. This was the first year data on smolt production was available. Production of age I smolt from the 1981 spawning escapement was high (34.6 smolt per spawner).

Two separate distributions of smolt abundance were noted during the season: one during 27 May to 12 June (maximum abundance, 6 June) and another during 13 to 30 June (maximum abundance 16-18 June). Mean lengths and weights of smolt migrating seaward during 27 May to 12 June were less than those of smolt migrating seaward during 13 June to 30 June (Tables 3 and 4). These two abundance distributions may have represented smolt populations produced by two different spawning stocks within the system.

A total of 1,829 smolt were sampled for length, weight, and age data (Table 4). Mean lengths of age I and II smolt were 79 and 92 mm, respectively. Mean weights of age I and II smolt were 4.7 and 7.2 g, respectively. These mean lengths and weights were similar to the grand means for past years (Table 5).

Climatological and hydrological observations were recorded at the sonar site from 26 May until 30 June (Table 6). Ice covered Nuyakuk Lake when the sonar project began, but melted in place during the first week of operations. Mean air and water temperatures for the season were 11.7 and 5.9^{o}C, respectively.

LITERATURE CITED

Cochran, W.G. 1963. Sampling Techniques. Second Edition. John Wiley and Sons, New York, New York, USA.

Huttunen, D. 1980. 1978 Bristol Bay special sockeye salmon smolt studies. In C.P. Meacham, editor. 1978 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 44, Juneau, Alaska.

Minard, R. Eric. 1984. 1982 Nushagak and Nuyakuk River sockeye salmon smolt studies. Pages 69-72 in D.M. Eggers and H.J. Yuen, editors. 1982 Bristol Bay sockeye salmon smolt studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 103, Juneau, Alaska.

Table 1. Sonar counts recorded from three 10 transducer arrays at the sockeye salmon smolt counting site on the Nuyakuk River, Bristol Bay, Alaska, 1983. False counts were deleted, and interpolations were made for time missed when sonar not operated.

	Sonar Counts			
	Transducer Array			
Date a/	Inshore	Center	Offshore	Total
5 27	115	57	99	271
5 28	349	176	219	744
5 29	378	341	247	966
5 30	478	354	250	1,082
5 31	592	555	485	1,632
6 1	1,743	1,186	644	3,573
6 2	7,483	3,375	1,821	12,679
6 3	2,769	3,863	2,900	9,532
6 4	1,504	1,207	1,477	4,188
6 5	11,623	10,343	13,273	35,239
6 6	16,381	18,969	14,844	50,194
6 7	7,918	5,151	4,175	17,244
6 8	5,083	2,852	2,389	10,324
6 9	7,149	2,611	1,327	11,087
6 10	4,748	1,510	646	6,904
6 11	947	507	464	1,918
6 12	2,098	1,080	595	3,773
6 13	645	1,042	788	2,465
6 14	2,301	1,146	1,406	4,853
6 15	10,495	5,327	2,536	18,358
6 16	29,737	14,310	5,778	49,825
6 17	13,412	11,222	5,381	30,015
6 18	33,234	19,181	8,011	60,426
6 19	15,484	4,547	3,430	23,461
6 20	10,782	1,994	1,528	14,304
6 21	6,597	2,498	1,487	10,582
6 22	2,461	665	969	4,095
6 23	2,500	424	265	3,189
6 24	1,758	543	195	2,496
6 25	2,139	583	374	3,096
6 26	582	237	476	1,295
6 27	277	127	322	726
6 28	362	210	140	711
6 29	321	305	36	662
6 30	214	85	60	359
Total	204,659	118,583	79,027	402,268
Percent	50.88	29.48	19.65	100.00

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next

Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Nuyakuk River, Bristol Bay, Alaska, 1983.

	Age I		Age II		All Ages	
Date a/	Number	Percent	Number	Percent	Daily Total	Cumulative Total
5 27	22,887	98.61	322	1.39	23,210	23,210
5 28	62,105	98.61	874	1.39	62,979	86,190
5 29	96,452	98.61	1,358	1.39	97,811	184,001
5 30	96,881	98.61	1,364	1.39	98,245	282,247
5 31	188,538	98.61	2,655	1.39	191,193	473,441
6 1	254,589	98.61	3,585	1.39	258,175	731,616
6 2	993,672	99.72	2,767	0.28	996,440	1,728,056
6 3	951,806	99.72	2,651	0.28	954,458	2,682,514
6 4	293,651	99.72	817	0.28	294,469	2,976,984
6 5	2,690,796	99.72	7,495	0.28	2,698,292	5,675,276
6 6	5,114,864	99.72	14,247	0.28	5,129,111	10,804,388
6 7	1,567,914	99.72	4,367	0.28	1,572,282	12,376,670
6 8	986,802	100.00	0	0.00	986,802	13,363,472
6 9	1,056,615	100.00	0	0.00	1,056,615	14,420,087
6 10	526,777	100.00	0	0.00	526,777	14,946,865
6 11	128,942	100.00	0	0.00	128,942	15,075,807
6 12	234,313	100.00	0	0.00	234,131	15,309,939
6 13	158,637	100.00	0	0.00	158,637	15,468,577
6 14	250,556	89.00	30,967	11.00	281,524	15,750,101
6 15	935,065	89.00	115,569	11.00	1,050,634	16,800,736
6 16	3,511,337	89.00	433,985	11.00	3,945,323	20,746,059
6 17	1,549,100	89.00	191,461	11.00	1,740,562	22,486,622
6 18	3,186,248	89.00	393,805	11.00	3,580,054	26,066,676
6 19	1,378,893	98.67	18,633	1.33	1,397,527	27,464,203
6 20	904,917	98.67	12,228	1.33	917,145	28,381,349

-Continued-

Table 2. Daily number of sockeye salmon smolt migrating seaward, estimated with a sonar unit, Nuyakuk River, Bristol Bay, Alaska, 1983 (continued).

	Age I		Age II		All Ages	
Date a/	Number	Percent	Number	Percent	Daily Total	Cumulative Total
6 21	648,638	98.67	8,765	1.33	657,403	29,038,752
6 22	257,928	98.67	3,485	1.33	261,414	29,300,167
6 23	192,967	98.67	2,607	1.33	195,575	29,495,742
6 24	157,485	99.17	1,323	0.83	158,809	29,654,551
6 25	208,732	99.17	1,754	0.83	210,486	29,865,038
6 26	96,582	99.17	811	0.83	97,394	29,962,432
6 27	61,646	99.17	518	0.83	62,164	30,024,597
6 28	44,066	99.17	368	0.83	44,434	30,069,031
6 29	42,094	99.17	353	0.83	42,447	30,111,478
6 30	22,828	99.17	191	0.83	23,019	30,134,497
Total	28,875,158	95.82	1,259,339	4.18	30,134,497	

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 3. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Nuyakuk River, Bristol Bay, Alaska, 1983. Only period mean weights used for final calculations.

Date a/	Mean Weight of Smolt (g)	Smolt per Count
5 27	4.1	10.1
5 28	4.0	10.4
5 29	3.3	12.6
5 30	4.0	10.4
5 31	3.2	13.0
6 1	4.9	8.5
Period 1 Mean	3.4	12.2
6 2	no sample	-
6 3	4.3	9.7
6 4	3.8	10.9
6 5	5.4	7.7
6 6	4.8	8.6
6 7	4.0	10.1
Period 2 Mean	4.4	9.4
6 8	3.8	10.9
6 9	3.8	10.9
6 10	3.7	11.2
6 11	4.1	10.1
6 12	5.1	8.1
6 13	5.3	7.8
Period 3 Mean	4.3	9.7
6 14	5.7	7.3
6 15	6.1	6.8
6 16	5.7	7.3
6 17	4.1	10.1
6 18	5.8	7.2
Period 4 Mean	5.5	7.5

-Continued-

Table 3. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Nuyakuk River, Bristol Bay, Alaska, 1983. Only period mean weights used for final calculations (continued).

Date a/	Mean Weight of Smolt (g)	Smolt per Count
6 19	no sample	-
6 20	5.4	7.7
6 21	5.5	7.5
6 22	4.9	8.5
6 23	5.3	7.8
Period 5 Mean	5.2	8.0
6 24	5.3	7.8
6 25	5.1	8.1
6 26	4.9	8.5
6 27	4.7	8.8
6 28	4.9	8.5
6 29	no sample	-
6 30	4.4	9.4
Period 6 Mean	4.9	8.5

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Nuyakuk River, Bristol Bay, Alaska, 1983.

	Age I					Age II				
Date a/	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (gm)	Std Error	Sample Size
5 27	76	0.7	4.1	0.11	60	-		-		0
5 28	77	0.6	4.0	0.08	60	-		-		0
5 29	75	0.7	3.3	0.14	60	-		-		0
5 30	72	2.1	3.2	0.29	14	108	0.0	15.0	0.00	1
5 31	72	0.6	3.2	0.09	60	-		-		0
6 1	79	0.9	4.7	0.17	59	105	0.0	15.1	0.00	1
6 2	-		-		0	-		-		0
6 3	76	0.5	4.3	0.10	60	94	0.0	7.4	0.00	1
6 4	75	0.6	3.7	0.10	59	-		-		0
6 5	86	0.6	5.4	0.12	60	-		-		0
6 6	78	0.8	4.8	0.13	42	-		-		0
6 7	78	0.9	4.0	0.12	60	-		-		0
6 8	75	0.7	3.8	0.11	60	-		-		0
6 9	77	1.5	3.8	0.21	32	-		-		0
6 10	75	0.5	3.7	0.08	60	-		-		0
6 11	76	0.9	4.1	0.17	60	-		-		0
6 12	83	1.0	5.1	0.19	60	-		-		0
6 13	81	0.8	5.3	0.19	60	-		-		0
6 14	84	0.8	5.7	0.17	60	-		-		0
6 15	82	0.7	5.7	0.18	49	93	0.8	8.0	0.32	11
6 16	83	0.7	5.6	0.16	57	90	4.1	7.3	0.91	3
6 17	75	0.6	4.0	0.10	59	87	0.0	6.4	0.00	1
6 18	82	0.7	5.4	0.15	47	90	0.8	7.5	0.32	13
6 19	-		-		0	-		-		0
6 20	82	0.8	5.2	0.14	55	92	0.9	6.9	0.37	5

-Continued-

Table 4. Mean fork length (mm) and weight (g) of sockeye salmon smolt captured in fyke nets, Nuyakuk River, Bristol Bay, Alaska, 1983 (continued).

	Age I					Age II				
Date a/	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (gm)	Std Error	Sample Size
6 21	83	0.9	5.4	0.17	58	96	0.5	7.7	0.30	2
6 22	81	1.0	4.9	0.17	60	-		-		0
6 23	85	0.9	5.2	0.14	58	98	1.0	7.2	0.40	2
6 24	84	0.8	5.3	0.15	60	-		-		0
6 25	84	0.8	5.1	0.13	60	-		-		0
6 26	82	0.8	4.9	0.12	60	-		-		0
6 27	81	0.7	4.7	0.12	59	92	0.0	6.4	0.00	1
6 28	80	0.8	4.8	0.14	59	100	0.0	8.0	0.00	1
6 29	-		-	-	0	-		-		0
6 30	76	0.8	4.5	0.11	60	-		-		0
Totals					1,787					42
Means	79		4.7			92		7.2		

a/ Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day.

Table 5. Age composition of total migration, and mean fork length (mm) and weight (g) by age class, for sockeye salmon smolt, Nuyakuk River, Bristol Bay, Alaska, 1978, 1982, and 1983.

Year of Migration	Sample Dates	Sample Size	Age I		Age II		References
			Mean Length (mm)	Mean Weight (g)	Mean Length (mm)	Mean Weight (g)	
1978	18-19 June	350	71	4.3	85	5.8	Huttunen (1980)
1982	15 June- 9 July	208	76	3.9	96	6.8	Minard (1984)
		Mean	74	4.1	91	6.3	
1983	27 May-30 June	1,847	75	4.3	91	6.6	

Table 6. Climatological and hydrological observations made at sockeye salmon smolt counting site, Nuyakuk River, Bristol Bay, Alaska, 1983. A dash (-) indicates missing data.

Date	Cloud Cover a/		Wind Velocity (km/hr)		Mean Air Temp. (C)	Mean Water Temp. (C)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr			
5 26	4	1	8 NE	- -	4.5	2.5	clear
5 27	1	1	- -	- -	8.4	3.6	clear
5 28	1	3	8 NW	- -	8.6	3.6	clear
5 29	4	4	42 E	- -	7.3	3.9	clear
5 30	3	4	8 SE	- -	6.7	4.2	clear
5 31	4	4	33 E	- -	7.8	4.4	clear
6 1	4	2	8 NW	- -	7.8	4.4	murky
6 2	3	4	17 E	- -	10.0	4.4	murky
6 3	4	3	8 NW	- -	10.0	4.4	murky
6 4	5	1	calm	calm	12.8	4.4	murky
6 5	1	1	calm	calm	14.5	5.0	murky
6 6	1	1	calm	calm	13.9	5.0	brown
6 7	1	1	calm	17 NE	15.3	5.6	light brown
6 8	1	1	8 E	25 NE	15.0	5.6	clear
6 9	1	1	- -	33 NE	10.9	5.6	light brown
6 10	1	1	calm	calm	13.9	5.6	light brown
6 11	1	3	8 NE	33 NE	12.5	5.6	light brown
6 12	4	3	17 N	25 NE	11.1	5.3	light brown
6 13	4	3	8 NE	17 NE	11.7	6.7	light brown
6 14	4	2	calm	8 NE	10.6	6.7	light brown
6 15	4	2	calm	calm	12.2	6.7	light brown
6 16	2	2	calm	calm	12.5	6.7	light brown
6 17	1	3	calm	calm	16.4	7.8	light brown
6 18	1	4	calm	calm	18.1	8.4	light brown
6 19	2	3	calm	calm	12.8	8.4	light brown

-Continued-

Table 6. Climatological and hydrological observations made at sockeye salmon smolt counting site, Nuyakuk River, Bristol Bay, Alaska, 1983. A dash (-) indicates missing data (continued).

Date	Cloud Cover a/		Wind Velocity (km/hr)		Mean Air Temp. (C)	Mean Water Temp. (C)	Water Clarity
	0800 hr	2000 hr	0800 hr	2000 hr			
6 20	3	4	8 NE	calm	11.7	6.4	light brown
6 21	4	3	calm	8 NE	15.0	6.7	light brown
6 22	3	4	calm	17 NE	13.6	7.0	light brown
6 23	4	3	17 NE	25 NE	12.0	6.2	light brown
6 24	4	4	17 NE	17 NE	10.6	6.4	light brown
6 25	4	3	25 SW	25 SW	12.2	7.3	light brown
6 26	3	3	8 SW	25 SW	11.1	7.0	clear
6 27	4	2	17 NE	17 NE	11.7	7.5	clear
6 28	3	2	calm	17 -	13.9	7.5	clear
6 29	4	2	8 -	17-33 -	11.7	7.8	clear
6 30	2	4	0-8 -	0-17 -	12.5	7.8	clear

a/ 1 = cloud cover not more than 1/10
2 = cloud cover not more than 1/2
3 = cloud cover more than 1/2
4 = completely overcast
5 = fog

Because the Alaska Department of Fish and Game receives federal funding, all of its public programs and activities are operated free from discrimination on the basis of race, color, national origin, age, or handicap. Any person who believes he or she has been discriminated against should write to:

O.E.O.
U.S. Department of the Interior
Washington, D.C. 20240